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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 162

THE LOWER SILURIC SHALES

OF THE

MOHAWK VALLEY

BY

RUDOLF RUEDEMANN

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1912

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STATE OF NEW YORK

EDUCATION DEPARTMENT

New York State Education Department

Science Division, May 14, 1912

Hon. Andrew S. Draper LL.D.

Commissioner of Education

Sir: I have the honor to communicate to you herewith a manuscript entitled *The Lower Siluric Shales of the Mohawk Valley,* with accompanying plates. This work has been prepared by Dr Rudolf Ruedemann, Assistant State Paleontologist, and is the result of careful and protracted observations. I recommend it, subject to your approval, for publication as a bulletin of the State Museum.

Very respectfully

John M. Clarke

Director

STATE OF NEW YORK

EDUCATION DEPARTMENT

COMMISSIONER'S ROOM

Approved for publication this 15th day of May 1912

A. S. Draper

Commissioner of Education

Compliments of

JOHN M. CLARKE

Director State Museum and
State Geologist

STATE HALL, ALBANY, N. Y.

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THE LOWER SILURIC SHALES OF THE MOHAWK VALLEY

BY RUDOLPH RUEDEMANN

INTRODUCTION

While engaged in mapping the shales of the Saratoga and Schuylerville quadrangles of the State of New York, the writer has found that in order properly to correlate the formations of fossiliferous shales appearing there with the standard formations of the State, it would be necessary to trace their relation to the Utica and Frankfort shales through the Mohawk valley. In beginning this task in Schenectady county, an unexpectedly large and interesting fauna was found in the "Frankfort shale" of that county hitherto considered as practically barren. This discovery promised a safe conclusion as to the as yet unknown faunal and taxonomic relations of the Frankfort shale to the Utica shale on the one hand, and to the Lorraine beds on the other. The close faunistic and stratigraphic relations of the Frankfort shale to the Utica shale were early recognized in the work, and as the writer had previously (title 60[1], page 44) obtained evidence of the different faunal aspect of the "Utica shale" of the lower Mohawk from the typical shale at Utica, it was found desirable to include the Utica shale in the investigations.

[1] See Bibliography, p. 69.

It was further found that beds formerly considered by the author (op. cit., page 29) as representing one formation (the Magog), had to be divided into two units, the Canajoharie shale and the Snake Hill beds. These beds are not only in juxtaposition about the mouth of the Mohawk, but even intermingled in that much-folded territory, and we originally considered them as both belonging to the Mohawk series and therefore have described also the Snake Hill beds in this paper. Later work has, however, shown that the Snake Hill beds were deposited in the Levis basin upon the Normanskill shale and have been brought to the mouth of the Mohawk and in contact with the Canajoharie beds by the overthrusting and compression of the shales of the Levis basin. We have nevertheless added the description of the Snake Hill fauna in the present paper, first, on account of its present occurrence in the lowest Mohawk valley, then, because of the intermixture of Snake Hill beds with Canajoharie shale, and, finally, because of the faunal similarities suggesting their equivalence. The Snake Hill formation finds, however, its principal development in the area of the Schuylerville sheet, and will therefore be more fully described in the report on that region, soon to be published.

Evidence was soon obtained that the lower part of the Utica shale of the lower Mohawk valley is older than the typical Utica shale and probably of Trenton age, and it would have been desirable to also trace the Trenton limestone from its type section at Trenton Falls to its much smaller section in the lower Mohawk valley. Time was lacking for this undertaking but fortunately Doctor Ulrich has furnished us important data as to the Trenton limestone, and we are glad to acknowledge here our obligation to him not only for this information, but also for advice in the identification of fossils, and many valuable suggestions as to the broader bearings of the problem.

We are also under obligation to Mr David White for the valuable notes on the interesting seaweeds collected in the Schenectady shale (see page 73), to Prof. Bashford Dean, Dr L. P. Gratacap, Dr H. A. Pilsbry for advising us in regard to the problematic fossils from the Schenectady shale, here described (see page 74), to Prof. A. F. Foerste for information regarding certain brachiopods and to Dr E. O. Hovey for the loan of type specimens from the American Museum of Natural History.

HISTORICAL SKETCH

A perusal of the literature shows that the Utica and Frankfort shales have received scanty attention from geologists, quite obviously because they promise little, if any, results, the Utica shale fauna consisting largely of small species difficult of study. The Frankfort shale was declared by Vanuxem to be remarkably deficient in all organic remains excepting graptolites. A fairly full account of the two was given by Vanuxem in the *Geology of the Third District*. This astute observer distinguished the Utica slate and the Frankfort slate; the latter as a subdivision of the Hudson River group or Lorraine (Emmons), the other member being the Pulaski shale. He states that in his district (which included the Mohawk valley) the Utica slate is everywhere underlain by the Trenton limestone and overlain by the Frankfort shale and sandstone; that both the Utica and Frankfort beds enter his district from the first district on the lower Mohawk and are coextensive there, while the Pulaski shale first appears much farther west in Oneida county. The Utica slate is characterized as deep bluish black rock, generally fissile, exhibiting a brownish or dark chocolate color by weathering and associated with thin layers or flags of dark colored impure limestone, especially in the lower part of the mass. As characteristic fossils, that do not come up from the Trenton, are cited:

Triarthrus becki, Graptolites dentatus (either Dipl. foliaceus or Glossogr. quadrimucronatus), a mutation of Trocholites ammonius and Graptolites scalaris (Diplograptus and Climacograptus viewed from in front).

The Frankfort slate is stated by Vanuxem to change by imperceptible gradation from the Utica slate, "yet a separation would seem obvious from the fact that the dark blue or black color of the latter disappears in the usually light color of the former. While the Utica slate alternates at its lower part with thin beds of dark colored impure limestone, the Frankfort slate, on the contrary, alternates with a peculiar sandstone to which Professor Eaton gave the name of rubblestone; and while the Utica slate is calcareous, the Frankfort slate is wholly destitute of calcareous particles." He continues: "Both slate and rubblestone" (greywacke of Eaton, an impure argillaceous sandstone), "lose their bluish color when long exposed, and assume a dull dark gray, green or olive color, which is very characteristic of this rock, and by which it is readily

distinguished from the Utica slate, which as before mentioned, changes to a brown." Vanuxem comments on the thinning of the Frankfort beds westward and it is obvious from his remarks (page 61) that he also considered the greater part of the shales in the Hudson valley as of Frankfort age, largely on account of the intercalation of similar rubblestone or greywacke. He describes the Frankfort shale as remarkably deficient in organic remains, stating: "From the eastern end of the Helderberg to Oneida county, I have seen but one fossil shell in the whole mass." Only graptolites are said to be numerous in a few places; this statement, however, refers principally to the shale in the Hudson valley, which we no longer refer to the Frankfort beds. He also found a small specimen of Triarthrus becki and two of Trinucleus concentricus ("Cryptolithus").

In the middle Mohawk valley the Frankfort slate is capped by the Oneida conglomerate, but in the upper valley and to the west of the Adirondack region it is overlain by the Pulaski shale, or rather it is separated from the typical Pulaski shale by an "intermediate area" (Vanuxem, page 64) with a separate fauna which Vanuxem considered a lower subdivision of the Pulaski shales.

Hall, in volume 1, Palaeontology of New York, brought out the fundamental paleontologic data for the formation in question. He distinguished the faunas of the Utica slate and of the Hudson River group, the latter comprising all the horizons of the shales in the Hudson valley, including the Frankfort and Pulaski (Lorraine) beds.

In volume 3, Palaeontology of New York, Hall extended the term Hudson River group to "all the beds from the Trenton limestone to the Shawangunk conglomerate," a conception which was taken up by the textbooks and came into general use.

In an attempt to correlate the Normanskill shale with the Utica formation, Whitfield (title 7) cited several Normanskill graptolites (Didymograptus serratulus, Dicranograptus ramosus, Climacograptus bicornis) from the Utica shale of the neighborhood of Fort Plain in the Mohawk valley as proof of his contention. The writer has shown (1901, 1908) that this view is based on the wrong identification of these graptolites. It had, however, an important influence in inducing later authors to refer a large part of the shales of the Hudson valley to the Utica shale.

Walcott (title 9) in his "Utica Slate and Related Formations," distinguished the Utica epoch from the Trenton and Hudson River epochs and added a considerable number of new types (two species of the sponge genus Cyathophycus, species of graptolites of the genus Dendrograptus, Leptograptus annectans and a few other forms) to the list of hitherto known Utica species. In his "Catalogue of Fossils Occurring in the Utica Slate" (page 34), he brought the Normanskill shale with its graptolites into the Utica shale as an upper division. The geographic distribution of the Utica shale within and outside of New York was fully discussed by him. The presence of passage beds between the Trenton limestone and Utica slate in the region of the type section is also commented upon (page 10). The thickness of the Utica shale, before greatly underestimated, is given as over 600 feet at the type section.

Beecher published in 1883 (title 13) a list of fossils from the black shales near the old Dudley Observatory, at Albany, referring the beds to the Utica epoch and Ford, a year later, recorded the discovery of a few fossils (Graptolithus pristis, Gr. mucronatus, Triarthrus becki and Lingula curta) in the slaty and arenaceous rocks in the vicinity of Schenectady, which on the strength of this evidence he also considers as of Utica age, while the preceding authors (Vanuxem) had referred it to the Frankfort slate, respectively Hudson River shale (Mather, Emmons).

In 1890, Walcott in a paper on "The Value of the Term Hudson River Group," asserted the continuation of both the Utica slate and Frankfort shale into the Hudson valley, thereupon basing his argument for the extension of the term "Hudson River group" to all beds between the Trenton limestone and Upper Siluric. As before, he included the Normanskill shale in the upper Utica epoch or lower Frankfort. The fauna discovered by Beecher at the Dudley Observatory was correlated with the upper Utica and that from the glazed slates at Cohoes (whence Hall in Palaeontology of New York, volume 1, reports Ambonychia radiata, etc.) to the Frankfort shale. The important fact is pointed out that a well drilled at Altamont (Knowersville), 17 miles west of Albany, gave a thickness of 3475 feet for the strata between the Lower Helderberg limestone and the Trenton limestone. On account of its proximity this section allows a good estimate of the great thickness of the Utica and Frankfort shales in the lower

Mohawk region, which is only about 10 miles to the north over a continuous outcrop of Frankfort beds.[1]

Darton did not make any special study of the Utica and Frankfort beds for his "Geology of the Mohawk Valley" (1893).

Of great importance for the present work were the investigations of Prosser and Cumings (titles 33, 44). They described a number of sections through the Utica slate and the Frankfort beds (their Hudson River group) and demonstrated the great thickness of these groups in the Amsterdam quadrangle (Utica 950–1260, Frankfort 1200 +)[2]. Among other things, they made known in the Minaville section a complete transition from the Utica to the Frankfort beds. From the base of the Minaville section a fairly complete section can be obtained along Chuctenunda creek through the Utica down to the Trenton limestone and thus it has been possible for us to study a continuous section from the Trenton to the Frankfort in the lower Mohawk valley. A list of eighteen species is given for the Utica slate at Canajoharie, and a small faunule recorded from the Hudson River shale near the Schenectady pump station, namely, Triarthrus becki, Trinucleus concentricus, Plectambonites, sericeus, Orthis (Dalmanella) testudinaria, Orbiculoidea sp., Monticulipora (Prasopora) lycoperdon, crinoid segments and graptolites.

A few notes on the Frankfort shale sections along Moyer creek near Frankfort (the type section) and Ferguson creek near Utica were published by Theodore G. White in 1899 and the presence of Triarthrus becki, a small Orthis, a small Orthoceras and graptolites recorded in these sections.

Purely paleontologic papers on fossils from the Utica slate of the Mohawk valley were published in the decade of 1890–1900 by Beecher on Triarthrus becki and by Ruedemann on the development of graptolites, and a sessile Conularia. Ruedemann (title 36) also demonstrated that in the Utica shales of the Mohawk valley distinct evidence is found of marine currents following a northeast-southwesterly course.

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[1] The terms Trenton limestone, Utica and Frankfort shales are used in this introduction in their old meaning, not in the restricted conception given to them in this paper.

[2] Cumings (1900, page 462) measured an actual thickness of the Utica slate of 1160 feet in the Adebahr hill section.

In 1901, the author (title 47) in his bulletin on the Hudson River beds near Albany, correlated the Normanskill shale with the lower Trenton and argued on this account for the suppression of the term Hudson River group. He also pointed there (page 560) to the decrease of the thickness of the Trenton limestone eastward in the Mohawk valley and the rapid increase of the "Utica" shale in the same direction. In the following years the author also showed the presence of graptolite zones ranging from the top of the Cambric through the Beekmantown and Trenton to the Utica in the Hudson River shales. A broad belt of shales on the west side of the Hudson overlying the middle Trenton shales and Normanskill shales was still referred to the Utica shale; and the shales at Cohoes and to the west of the Utica belt were in accordance with Hall and Vanuxem correlated with the Frankfort division of the Lorraine group, mainly on the ground of a series of small lamellibranchs obtained about Cohoes and of the supposed upper Utica aspect of the Dudley Observatory faunule.

In 1902 Paleozoic Seas and Barriers in Eastern North America by E. O. Ulrich and Charles Schuchert was published. This very important paper, which apparently has not been sufficiently understood or appreciated by many, has helped greatly in the elaboration of the complex shale problems by pointing to the existence of separate troughs or channels in the shale region (the Chazy and Levis troughs) of New York and to the draining of these channels independently of each other.

Clarke in the Classification of the New York Series of Geologic Formations (title 52) discarded the term Hudson River and distinguished the Utica shale and Lorraine beds as stages of the Cincinnatian; the Frankfort shale, Pulaski and Salmon River being considered as "early terms applied to the local development of these beds in central New York."

In an excellent description of the Geology of Little Falls, Cushing (1905) pointed out the presence of 100 feet of passage beds between the Trenton and Utica. He says: "Lithologically these beds are no more Trenton than they are Utica but are distinctly intermediate in character, and no more to be classed with the one formation than with the other." He mapped them as a distinct unit, and in a later communication to Professor Miller (title 65, page 21) he proposed the term *Dolgeville shale* for these passage beds, considering them a formation "as a shaly eastern representative of the upper Trenton limestone of the type section."

These beds were found by Miller (title 65) to be absent on the Remsen quadrangle which adjoins the Little Falls quadrangle to the west.

The graptolites of the Utica shales and supposed Frankfort beds of the Hudson valley have been fully described by the author in volume 2 of Graptolites of New York (1908). The Utica shale is there characterized as the zone of Glossogr. quadrimucronatus and Climacograptus typicalis. The presence of subzones and the difference of the faunas in different districts especially that between the fauna of Holland Patent and the lower Mohawk is pointed out, and the fact brought out (page 36) that the Utica faunules of the Appalachian trough differ from those of the Mohawk valley by the frequent occurrence of Corynoides calicularis[1] which latter only enters the lower Mohawk valley. The transgression of the Utica shale from the northeast is inferred from the faunal evidence and as corollary of this transgression the conclusion drawn (page 49) that the boundary between the Trenton limestone and Utica shale is not a plane of synchrony, and that the areal restriction of the Corynoides to the lower Mohawk valley may be due to the greater age of the eastern Utica beds and its absence farther west, or to the replacing of the shale by the lower Trenton limestone. The Utica of the Hudson valley is thought to be separated by the Magog shales from the lower Trenton Normanskill shale.

The faunule of the Frankfort shale is described from the supposed Frankfort beds at Waterford and Mechanicville.

In a paper by Grabau on the Physical and Faunal Evolution of North America during Ordovicic, Siluric and early Devonic Time (1909) the relations of the Trenton and Utica are stated as follows:

The Trenton limestone of America is not a stratigraphic unit, but, as has been repeatedly demonstrated by Ruedemann and noted by many observers, it is the limestone phase of a series which elsewhere is in part or mostly represented by Utica shale. In the Mohawk valley the dividing line between Utica and Trenton is a line constantly rising to the west, the transition being in some cases abrupt, though probably in most cases it is gradual. Ruedemann has pointed out the progressive increase in thickness westward of the limestone, and corresponding decrease in the shale; the former increasing from 40 feet at Saratoga to 430 feet at Utica, and to 954 feet at Rochester, while the latter decreases from 1260 feet to 710 feet to probably zero over the same localities. . . . The

[1] Erroneously there referred to C. curtus.

various sections clearly show that along the western border of the Appalachians, dark graptolite shales continued to form in Upper Ordovicic time, while westward from this the Trenton limestone represents the calcareous phase of the Utica-Trenton series (see map, figure 8).

In a diagram that accompanies Professor Grabau's paper (op. cit. figure 9), the Utica is represented as wholly replaced by Trenton limestone in the latitude of Rochester and farther west.

In the description of the Remsen quadrangle Miller (title 65) has shown the absence of the Dolgeville beds in the area adjoining the Little Falls quadrangle to the west. He found the Utica to be only 300 feet thick indicating a notable thinning to the northwest from the type section. Two hundred feet of Lorraine beds were observed which were found to be destitute of fossils and are not separated by an exact boundary line from the Utica. There is little doubt that these beds are the Frankfort shale. This decrease is in a later bulletin (title 66) by the same author shown to be steady toward the north. It would also become probable from the same paper that the Frankfort shale with a thickness of about 200 feet continues to the northwest and intervenes there between the Utica shale and Lorraine sandstones and shales with the characteristic Lorraine fauna (page 33).

To the south of New York, in New Jersey, Pennsylvania and West Virginia, the shales which formerly were termed "Utica and Hudson River slates" are now known as Martinsburg shale. The Martinsburg shale of the Mercersburg-Chambersburg quadrangle in Pennsylvania has been described by Stose, and fossil lists given by Ulrich (title 61, page 10). The lowest shale fauna is considered as indicating an age corresponding to that of the lower to middle Trenton of New York, and the highest as comprising species characterizing the Eden shale.

Bassler, in his work on the Cement Resources of Virginia (title 62), the Federal Survey's part of which was done under the official direction of Doctor Ulrich, divides the Martinsburg shale in three divisions, namely, upper Trenton shale, Utica shale and Eden shale, representing the shaly Ordovicic deposits of the Appalachian trough. The Martinsburg is continuous from Virginia through Pennsylvania and New Jersey with the shale belt of New York, and this division of the shales has a direct bearing on that of the shale in the New York part of the Appalachian trough, represented by the shales in the Hudson valley.

Schuchert (1910), in his monumental Paleogeography of North America, refers the Utica of New York as the zone of the Mastigograptus fauna to the top of his Ordovicic period. As characterizing the shale facies of the Trenton in the Atlantic province are cited the Climacograptus caudatus, Corynoides curtus and Magog graptolite zones, while the horizon of the Normanskill shale is correlated with the Black River of New York and Kimmswick of Illinois and Missouri. The Frankfort is correlated with the Edenian and placed in the Cincinnatic period, the Ordovicic period being considered as closed by the Utica emergence. Paleogeographic maps of North America in the late Trenton and Utica stages by Ulrich and Schuchert are given, to which we will have occasion to refer.

A new light has been shed on many problems, here involved, in the Revision of the Paleozoic System by E. O. Ulrich (title 68), the first volume of which appeared after this paper was written, but as much of the information therein published was freely given to the author in the joint field excursions in the Mohawk and Hudson valleys, its principles have been applied to a considerable extent to the questions that arose in this investigation and the conclusive answers obtained are clear evidence of the truth of some of these principles. We have here especially in mind Ulrich's theories of a multiplicity of shallow continental seas and of frequent and periodic migrations of faunas from their permanent oceanic habitats into these inland seas.

In the investigation of the Utica and Frankfort shales in the Mohawk valley, the entire mass of shales between the Trenton limestone at the base and the Upper Siluric rocks on the top were studied in the region from Cohoes at the mouth of the Mohawk to the neighborhood of the city of Utica and of Holland Patent. In the lower Mohawk region for the most part a broad plain of deep drift intervenes between the Mohawk river bluffs and the foot of the Helderberg escarpment; only two sets of sections were therefore accessible in greater numbers, one at the base of the shales in the ravines near the mouths of the southern tributaries of the Mohawk and another in the upper Frankfort beds in the ravines cut into the lower slopes of the Helderberg escarpment. The Chuctenunda creek furnished here the most satisfactorily continuous section, leading from the Trenton limestone to the Schenectady beds. The Canajoharie creek and Flat creek at Sprakers afford two excellent sections through the lower "Utica beds" (here distinguished as

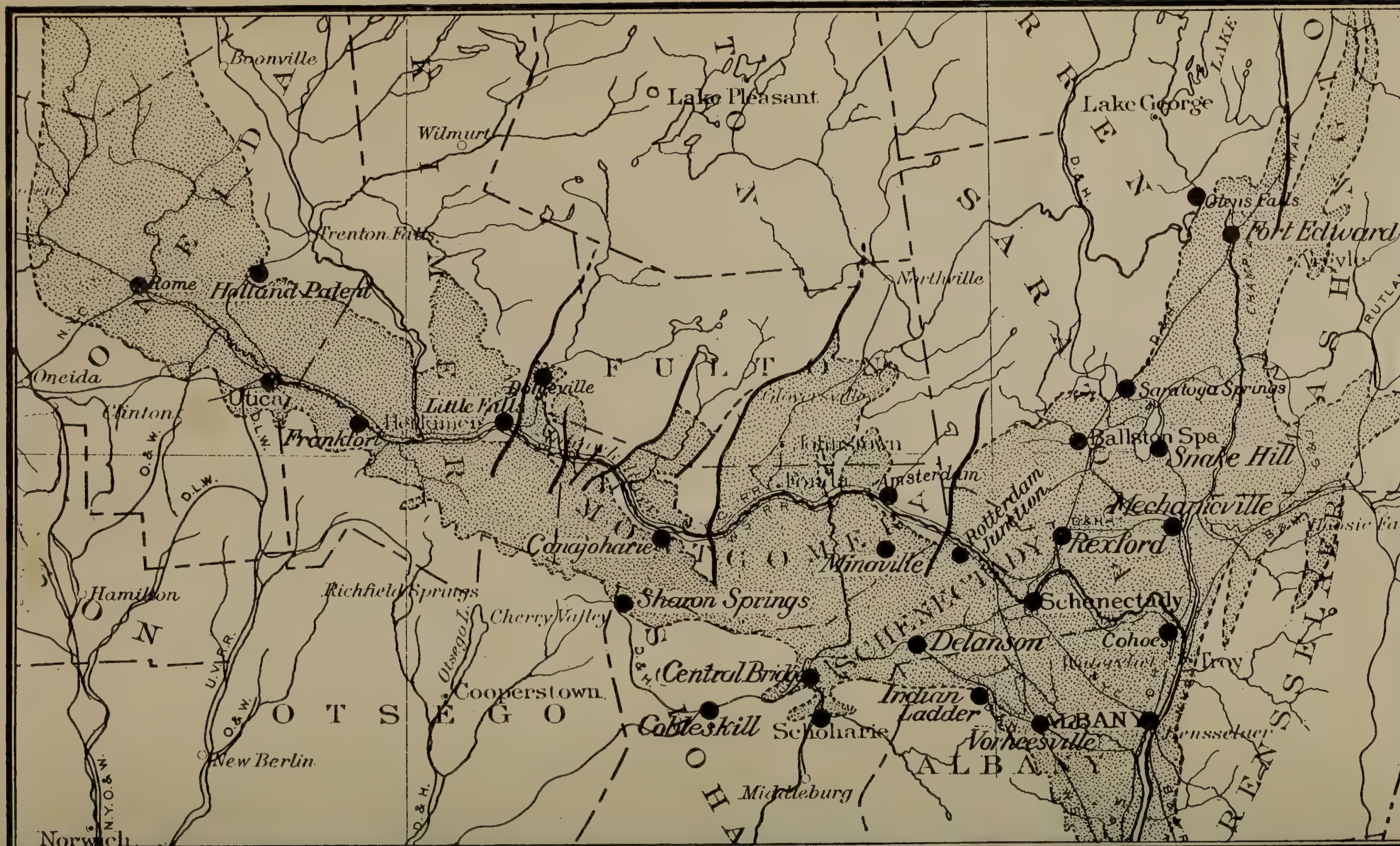

Figure 1 Locality map of the Shale belt in the Mohawk and Upper Hudson valleys. The shale area is shaded.

Canajoharie beds), the East Canada creek one from the Trenton through the transition beds into the lower Utica, while Moyers creek at Frankfort and the " Gulf " at Ilion give excellent sections through the Frankfort shale but fail to show its base. No continuous Utica section has been found in the neighborhood of Utica; the name according to Vanuxem is derived from the exposures in the Starch Factory creek (page 58, " a creek to the east of the city "), now largely within the city. The most important of these sections are here discussed in detail.

"UTICA" SHALE OF AUTHORS[1]

The belt of black " Utica " shale that follows the south side of the Mohawk valley is cut off by the Hoffman Ferry fault, as is well shown in the geologic map of the Amsterdam quadrangle by Prosser, Cumings and Fisher, to be replaced by an area of " Hudson River " or " Frankfort " beds that occupies nearly all Schenectady county and toward the east merges into the zone of folding. Just west of this fault, between Hoffman Ferry and Amsterdam, the south bank of the river is formed by cliffs of Little Falls dolomite and Trenton, above which, according to Prosser and Cumings, the contact of the Trenton and " Utica " is seen in several places, which have been visited by the writer.

In the *Swartztown creek section* (title 45, page 472; title 44, page 457) two feet of black partly noncalcareous, but mostly calcareous shale[2] is exposed overlying very fossiliferous Trenton. The contact in this section which is the first west of the Hoffman Ferry fault is disconformable and the surface of the Trenton irregular. The fossils are:

Corynoides calicularis *Nicholson*
Dicranograptus nicholsoni *var.* parvulus *nov.*
Diplogr. (Mesogr.) mohawkensis *nov.*

A mile farther west is a section opposite Cranesville (title 33, page 653) in which about 21 feet of basal Trenton, overlying the Amsterdam limestone (formerly Black River) with

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[1] It will be shown in this paper that both the Utica shale and Frankfort shale of the lower Mohawk valley are of another, earlier, age than hitherto supposed. They will therefore, in distinction from the true Utica and Frankfort shales, be cited in quotation marks, until differently named.

[2] The " Utica " shale is described as calcareous in distinction from the Frankfort shale. The two have therefore been distinguished by Professor Prosser in the field by the use of the acid bottle.

a little of the calcareous basal Utica shale, is shown. This again contained Corynoides calicularis and Diplogr. (Mesogr.) mohawkensis.

An excellent section of the Trenton and basal "Utica" shale is exposed in *Morphy creek,* (title 33, page 654; title 44, page 460) halfway between Cranesville and Amsterdam and about one and one-half miles west of the preceding section. Here 5 feet of Amsterdam limestone are overlain by 37 feet of Trenton limestone. The uppermost 27 feet are thin, irregular, dark blue, limestone layers with very black shale intercalations. These beds abound in Prasoporas, Trinucleus concentricus, Calymmene senaria, but contain no graptolites. The black calcareous Utica shale follows abruptly with profusely graptolitiferous beds, the species being:

Dicranograptus nicholsoni *var.* parvulus *nov.*
Diplogr. (Mesograptus) mohawkensis *nov.*
Diplogr. *cf.* putillus (*Hall*)
Rafinesquina alternata (*Emmons*) (small)
Leptobolus insignis *Hall*
Orthoceras *sp.*

It follows from this series of outcrops that the Lower Trenton or Prasopora zone at the eastern terminus of the continuous "Utica" belt of the Mohawk valley is separated by a disconformity indicating a small interval of nondeposition, from black calcareous shales characterized by Corynoides calicularis and a characteristic Diplograptus of the Mesograptus group. All three of these ravines reach the drift directly above the basal "Utica" beds and no satisfactory section of the upper "Utica" could be obtained. The latter is found along the south branch of the *Chuctenunda creek,* which empties opposite Amsterdam, and reaches back into the "Frankfort" shale hills, southwest of the village of Minaville where the transition from the "Utica" shale into the "Frankfort" shale is finely exposed in the ravines.

The contact between the Trenton and "Utica" is not shown in the section; the first outcrop is found at the falls of the creek, probably not more than 20 feet above the top of the Trenton. Here were found (Museum locality number 3758):

[1] Diplograptus amplexicaulis	(cc)
Diplograptus (Mesograptus) mohawkensis	(c)
Lasiograptus eucharis	(r)
Leptobolus insignis	(r)

[1] cc = very common, c = common, r = rare, rr = very rare.

The next outcrop which furnishes fossils is in a small creek, coming in from the west, at the second bridge above 1, about 220 feet higher in the section. Here were found (Mus. loc. 3759):

2	Corynoides calicularis	(cc)
	Diplograptus foliaceus acutus	(cc)
	Triarthrus becki	(c)

A third fossiliferous outcrop was found along the main Chuctenunda creek one and three-fourths miles west by south, 70 feet above the preceding. This has furnished (Mus. loc. 3760):

3	Diplograptus (Mesogr.) mohawkensis	(cc)
	Lasiograptus eucharis (with colonies)	(cc)
	Leptobolus insignis	(c)
	Triarthrus becki	(r)
	Orthoceras *sp.*	(r)

There follow continuous outcrops for half a mile, all of which contain (Mus. loc. 3761):

4	Diplograptus (Mesogr.) mohawkensis	(cc)
	Lasiogr. eucharis	(cc)

At the end of this series of outcrops, about 30 feet above 3, (Mus. loc. 3762) Lasiograptus eucharis has become by far the prevailing fossil. There occur:

5	Diplograptus (Mesogr.) mohawkensis	(c)
	Lasiograptus eucharis (colonies)	(cc)
	Leptograptus insignis	(r)

A quarter of a mile farther up, beyond the fourth bridge (Mus. loc. 3763) the following fossils were obtained:

6	Diplograptus (Mesogr.) mohawkensis	(c)
	Lasiograptus eucharis	(cc)
	Leptobolus insignis	(r)
	Triarthrus becki	(c)

Three-quarters of a mile farther up, (Mus. loc. 3764), just below the village of Minaville and 300 feet above the first outcrop only

7 Lasiograptus eucharis, and
Leptobolus insignis

were collected. The next outcrop which is half a mile above Minaville is the base of the Minaville section, described by Cumings

(title 44, page 463). Here in black, slabby calcareous shale were collected (Mus. loc. 3765):

8 Climacograptus *cf.* putillus
Lasiograptus eucharis
Leptobolus insignis

In a gully about one and two-fifths miles south by southwest of Minaville a continuous section 255 feet thick is exposed, which exhibits a complete transition from the typical lithologic character of the "Utica" to that of the "Frankfort." This section has been measured by Cumings and the following lithologic divisions distinguished:

K4 Mostly covered. Thin sandstone and arenaceous shales with a massive 2 foot layer at the base in the head of the glen. 120′ = 540′

K3 Black shales becoming olive to blackish at the top. These shales show a transition from the black calcareous shales of the "Utica" to the arenaceous, thin, crumbling shales of the "Hudson River" stage. 165′ = 420′

K2 Top consisting of slaty layers containing graptolites in abundance. Black, even shale. 90′ = 255′

K1 Mostly covered, but showing brown in weathering, slabby shale in the west bank of Chuctenunda creek, just above Minaville. 165′ = 165′

While K1 of this section has furnished the faunule cited under 8, the following division K2 was found to contain still, at least in its lower part (Mus. loc. 3770), specimens of

9 Diplogr. (Mesogr.) mohawkensis

Near the top (Mus. loc. 3769) a zone appears that is characterized by

10 Climacograptus spiniferus (cc)
Lasiograptus eucharis

K3 proved fossiliferous in one part (Mus. loc. 3768) where

11 Climacograptus spiniferus

occurs in great profusion.

The shales in this division, although still carbonaceous and very black like the "Utica" shale, do not any more react with HCl and are not calcareous.

K4, which consists prevailingly of thin sandstone and arenaceous shales of "Frankfort" aspect, still contains bands of black argillaceous shale, which usually yield graptolites on examination. At the base (120 feet from the top sandstone layer of the section) a band (Mus. loc. 3767) has furnished:

12	Climacograptus typicalis	(c)
	Lasiograptus eucharis	(cc)

The Lasiograptus eucharis occurs in an unusually large and broad mutation.

Another graptolite horizon was found but 22 feet from the top (Mus. loc. 3766). This contains:

13	Diplograptus (Amplexograptus) macer nov.	(c)

The graptolite that characterizes this fauna is an extremely narrow and long form, hitherto not observed at other horizons and therefore here distinguished by a new specific term (see Paleontologic notes, p. 82).

A survey of these localities as little suggests any sharp faunal boundaries as do the lithologic characters of the rocks. The rock is a black brownish weathering shale that strongly reacts with HCl. This character does not change until K3 (with horizon 11) is reached, when the black shale becomes wholly argillaceous. Nevertheless there is distinct though gradual change in the faunal aspect of the Utica shale as one passes upward. The basal beds at Morphy's and Swartztown creeks were found to be characterized by Corynoides calicularis and Diplograptus mohawkensis, two fossils which are wholly foreign to the Utica beds of the Utica section, or to the typical Utica beds. Corynoides calicularis is in the Chuctenunda section still abundantly found 220 feet above the base. Diplograptus mohawkensis remains the most common fossil, much longer, through 3 and 4, but in 5 it is replaced by Lasiograptus eucharis which remains the dominant graptolite to near the beginning of the transition beds, where it is somewhat abruptly displaced by Climacograptus spiniferus, (in 10) which hitherto had not been observed in the section. Then also Climacograptus typicalis appears and at the top a new species of Diplograptus. We may add that Lasiograptus eucharis, Climacograptus spiniferus and Climacograptus typicalis continue into and through the "Frankfort" shale in the lower Mohawk valley.

We can then distinguish three larger faunal zones, namely:

1 That of Diplograptus mohawkensis
Corynoides calicularis
2 That of Lasiograptus eucharis
3 That of Climacograptus spiniferus
Climacograptus typicalis
Diplograptus macer

All three of these zones are absent in the typical Utica section.

Another series of sections through the "Utica" shale, or at least its lower part, is afforded by the gulfs of Flat creek at Sprakers and of Canajoharie creek at Canajoharie. These places are about 20 miles west of the Chuctenunda sections and halfway between the latter and the typical Utica section of the Utica region.

The *Canajoharie creek and Sprakers sections* have been briefly described by Prosser and Cumings (title 33, page 638). They record at the former 53 + feet of Tribes Hill (Fucoidal) limestone, underlying 17 feet of thin bedded dark blue, very fossiliferous Trenton limestone with shaly partings. A distinct unconformity separates the two. About 300 feet of very black, bituminous slate referred to the lower "Utica" formation were found in the glen. The following fossils are cited from the Trenton:

1	Rafinesquina alternata (*Con.*), *Hall and Clarke*	(c)
2	Calymmene callicephala *Green* (?)	(r)
3	Orthis (Dalmanella) testudinaria *Dalm.*	(a)
4	Asaphus platycephalus *Stokes*	(c)
5	Monticulipora (Prasopora) lycoperdon *Say.*	(r)
6	Modiolopsis mytiloides *Hall* (?)	(rr)
7	Tellinomya levata *Hall*	(rr)
8	Zygospira recurvirostris (*Hall*), *Winch. and Schuch.*	(rr)
9	Plectambonites sericeus (*Sowb.*), *H. and C.*	(c)
10	Trinucleus concentricus *Eaton*	(r)
11	Atrypa (Protozyga) exigua *Hall*	(rr)
12	Ceraurus pleurexanthemus *Green* (?)	(rr)
13	Murchisonia bellicincta *Hall*	(rr)
14	Murchisonia gracilis *Hall* (?)	(rr)
15	Camarella *cf.* volborthi *Bill.*	(rr)
16	Stictopora *sp.*	(r)

and the following from the "Utica" which is stated to contain a larger number of fossils than has been found in the more eastern exposures:

1	Lingula quadrata (*Eich.*), *Hall* (?)	(c)
2	Plectambonites sericeus (*Sowb.*), *H. and C.*	(a)
3	Orthis (Dalmanella) testudinaria *Dalm.*	(c)

4	Triarthrus becki *Green*	(c)
5	Graptolites	(a)
6	Asaphus platycephalus *Stokes*	(r)
7	Tellinomya nuculiformis *Hall*	(r)
8	Pterinea trentonensis (*Conrad*)	(rr)
9	(?) Edmondia subtruncata (*Hall*)	(rr)
10	Endoceras proteiforme *Hall*	(c)
11	Raphistoma lenticulare (*Emmons*)	(r)
12	Trocholites ammonius *Conrad*	(r)
13	Rafinesquina alternata (*Con.*), *H. and C.*	(r)
14	Orthis (Dinorthis) pectinella *Emm., var.* semiovalis, *Hall*	(rr)
15	Crinoid segment	(rr)
16	Leptobolus insignis *Hall*	(r)
17	Lingula curta *Con.*	(a)
18	Monticulipora (Prasopora) lycoperdon *Say.*	(rr)
19	Bellerophon *sp.*	(rr)

With the exception of a bed of compact barren limestone at the base, which has an irregular surface and is separated by an unconformity from the overlying beds, the Trenton is composed of thin beds of limestone alternating with layers of shale of equal thickness, the whole having a distinctly transitional character like the beds designated as *Dolgeville beds* by Cushing. A limestone near the base is a shell-breccia and contains the brachiopods and trilobites cited by Prosser. This is followed by a thin bryozoan reef, from which Doctor Ulrich has identified:

Stictoporella *cf.* angularis *Ulrich*
S. exigua *Ulrich*
Phaenopora incipiens *Ulrich*
Pachydictya acuta (*Hall*)
P. pumila *Ulrich*
Eridotrypa mutabilis *var.* minor *Ulrich*

A small reef of broken shells swept up by a current, passes through the shaly Trenton limestone. This is especially rich in fossils and has furnished (*fide* Doctor Ulrich):

Corynotrypa inflata (*Hall*)
Atactoporella ? crassa *Ulrich*
Stomatotrypa ? *sp.*
Eridotrypa mutabilis *var.* minor *Ulrich*
Phylloporina reticulata (*Hall*)
Nematopora ovalis *Ulrich*
Arthroclema pulchellum ? *Billings*
Rhinidictya canadensis *Ulrich*
Pachydictya acuta (*Hall*)

P. pumila *Ulrich*
Stictoporella *cf.* angularis *Ulrich*
S. exigua *Ulrich*
Phaenopora incipiens *Ulrich*
Dalmanella futilis (*Sardeson*) *var.*
Rhynchotrema increbescens (*Hall*)
Eurychilina subradiata *Ulrich var.*
Calymmene senaria *Conrad*
Pterygometopus callicephalus (*Hall*)
Trinucleus concentricus (*Eaton*)

The shaly intercalations have afforded us:

Rafinesquina alternata (*Emmons*)	(c)
Leptobolus insignis *Hall*	(c)
Lingula curta (*Conrad*)	(c)
Dalmanites (Pterygometopus) callicephalus *Hall*	(r)
Diplograptus amplexicaulis *Hall*	(cc)
Diplograptus (Mesogr.) mohawkensis	(c)
Corynoides calicularis *Nicholson*	(r)
Ctenodonta *cf.* nuculiformis *Hall*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(r)
Small ostracods of Primitia type	

It will be noted that the shaly intercalations of the Trenton limestone contain two of the most characteristic graptolites cited above from the basal " Utica " shale in the neighborhood of Amsterdam. Likewise it will be seen that also in the Canajoharie section these graptolites and all the other fossils observed in these shaly intercalations go up into the black " Utica " shales.

The fauna of both the limestone and the shaly intercalations is of earliest or basal Trenton age.

This belt of basal Trenton limestone with the underlying Amsterdam limestone can be traced by outcrops, rather widely separated through the faulting of the region, around the southeast side of the Adirondacks to Saratoga and Glens Falls. Since these beds are lower than any exposed at Trenton Falls, their reference to the Trenton is likely to lead to confusion and they should be recognized by a distinct name. For a time we have termed them the Jacksonburg limestone, but since the latter unit, recognized in New Jersey (title 59), also comprises beds of Amsterdam and Lowville age, it is not properly applicable to the limestone in question. As the latter is best exposed at Glens Falls with the underlying Amsterdam (Black Marble) limestone and overlying Canajoharie shale, we propose for it the term *Glens Falls limestone*.

The first 65 feet of the beds at Canajoharie (from the Glens Falls limestone to the lower falls) consist of calcareous shale with frequent small limestone seams near the base. The shale is deep black, calcareous, hard and splintery, brownish weathering. It contains:

Diplograptus amplexicaulis *Hall*	(cc)
Leptobolus insignis *Hall*	(c)
Schizocrania filosa *Hall*	(c)
Lingula curta *Conrad*	(c)
Calymmene senaria *Conrad var.*	(c)
Ctenodonta nuculiformis ? *Hall*	(r)
Primitiella unicornis *Ulrich*	(r)

An extremely rich zone was observed in the cliff directly above the falls (65–120 feet from base). This has furnished:

Diplograptus amplexicaulis (*Hall*)	(cc)
Corynoides calicularis *Nicholson*	(c)
Diplograptus (Mesograptus) putillus *Hall*	(r)
Lasiograptus eucharis (*Hall*)	(c)
Sponge spicules	
Spatiopora *sp.*	
Leptobolus insignis *Hall*	(c)
Lingula curta *Conrad*	(r)
Dalmanella testudinaria (*Dalman*)	(c)
Rafinesquina alternata (*Emmons*) small	(c)
Plectambonites sericeus (*Sowb.*) H. & C.	(c)
Hyolithes pinniformis *nov.*	(c)
Prolobella ? trentonensis (*Hall*)	(c)
Pterinea insueta[1] (*Emmons*)	(r)
Ctenodonta *cf.* nuculiformis (*Hall*)	(c)
Clidophorus *sp.*	(c)
Ctenodonta *sp. nov.* large	(rr)
Whiteavesia *sp.*	
Clathrospira subconica (*Hall*)	(c)
Liospira *cf.* rotuloides (*Hall*)	(c)
Orthoceras *sp.*	(r)
Calymmene senaria (*Conrad*)	(cc)
Lepidocoleus jamesi (*Hall & Whitfield*)	(c)
Turrilepas filosus *Ruedemann*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(cc)
Minute Primitias	

[1] This last species, described by Hall in Paleontology New York, 1:291, is known only from this locality. Hall states of it: "This species occurs in the lower black shale, or Utica slate, at Canajoharie, and is known in the higher part of the group."

A third series of outcrops begins with a cliff on the north side of the creek, about 115 feet above the base and reaches to 150 feet. The shales of this are lithologically identical with the underlying rock. These beds contain:

Cyathodictya ? tubularis *nov.*	(cc)
Glossograptus quadrimucronatus *mut.* cornutus *Rued.*	(c)
Diplograptus (Mesograptus) putillus *Hall*	(cc)
Lasiograptus eucharis (*Hall*)	(r)
Spatiopora *sp.*	(r)
Leptobolus insignis *Hall*	(c)
Lingula curta *Hall*	(c)
Rafinesquina alternata (*Emmons*)	(r)
Orthoceras *sp.*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(c)

The most novel element of this association is Glossograptus quadrimucronatus mut. cornutus. This characteristic form has before been known to us only from the Rural Cemetery beds near Albany which we had referred in Bulletin 42 to the Utica. It is there associated with Diplogr. (Mesogr.) putillus and Corynoides calicularis. It is safe to infer on the strength of this form that the Rural Cemetery beds and this portion of the Canajoharie beds belong to the same horizon. Some layers are profusely covered with the problematicum termed here Cyathodictya? tubularis. This fossil is described in the paleontologic notes at the end of this paper.

The fourth series of beds is exposed in a cliff reaching from 150 feet above the base to about 270 feet. These beds contain:

Cyathodictya ? tubularis *nov.*	(c)
Corynoides calicularis *Nicholson*	(cc)
Glossogr. quadrimucronatus *mut.* cornutus *Rued.*	(cc)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Prasopora simulatrix *Ulrich*	(c)
Lingula curta *Hall*	(c)
Triarthrus becki *Green*	(cc)
Calymmene senaria *Conrad*	(r)
Ulrichia ? bivertex *Ulrich*	(c)

Triarthrus becki, which before had not been noticed, appears in this last division about 40 feet from the base in great numbers. Glossograptus quadrimucronatus mut. cornutus and Corynoides calicularis

were found near the top of this last cliff with which end the outcrops in the Canajoharie gulf.

A series of exposures which to a large degree is complementary to the one just described is afforded by the *Flat creek ravine at Sprakers,* two and one-half miles east of the Canajoharie ravine. The Glens Falls limestone is finely exposed in this section. It is 17 feet thick and consists of thin layers of very fossiliferous limestone with shale intercalations near the top and a two-inch conglomeritic layer at the base, separating it from the Tribes Hill (Fucoidal) limestone. The limestone beds exhibit large ripple marks, small piles of current-swept pebbles and other signs of shallow water conditions. Besides the fossils noted from the Canajoharie beds, Eurychilina subradiata was also collected.

The "Utica" shale comes in, notwithstanding the shaly intercalations of the upper Glens Falls beds abruptly as a black shale formation. It contains directly at the base:

Diplograptus amplexicaulis (*Hall*)	(cc)
Ctenodonta *cf.* nuculiformis (*Hall*)	(c)

1 Ten feet above the base abundant Diplograptus (Mesogr.) putillus and ostracods (Ulrichia ? bivertex, Primitiella unicornis, Primitia) were observed, which continued through 20 feet, where also layers with great numbers of Leptobolus insignis and limestone bands filled with Dalmanella testudinaria were observed.

2 The beds from 30–60 feet above the base furnished:

Diplograptus amplexicaulis	(cc)
Cyathodictya ? tubularis	(cc)
Leptobolus insignis	(cc)
Ctenodonta *cf.* nuculiformis	(c)

3 From 60 feet above base upward there were observed besides:

Diplograptus amplexicaulis	(cc)
Orthoceras *sp.*	
Lingula curta	(c)

4 75 feet above base besides Diplograptus amplexicaulis and the ostracods, specimens of Clathrospira subconica (Hall) were found.

5 From 110–20 feet Calymmene senaria occurs in great abundance and from 125–30 feet fragments of Isotelus and Prasoporas fill the beds. Also at about 135 feet above the

base is a bed of abundant small Prasoporas. It is important that this Prasopora, forming here an horizon, has been recognized by Doctor Ulrich as the lower Trenton Prasopora simulatrix.

6 Directly above this bed Triarthrus becki begins to be observed in considerable numbers and it continues to be the common fossil through a considerable thickness.

7 From 160–80 feet Triarthrus becki and Corynoides calicularis are the dominant fossils, while

8 At 210 feet above base Lasiograptus eucharis appears in great numbers and typical expression. It is associated with:

Triarthrus becki, and
Lingula curta

This association was observed to the top (230 feet) approaching which were found:

Sphenothallus angustifolius *Hall*[1]	(cc)
Dalmanella testudinaria (*Dalm.*)	(cc)
Schizocrania filosa *Hall* (in large specimens)	(c)
Trocholites ammonius *Hall*	(c)
Orthoceras *sp.*	(c)

This congeries is typically that observed in the lower "Utica" shale in the East Canada creek section at Dolgeville and it is notable that also the lithic character of the light drab weathering, blocky, polygonal breaking, thick-bedded mud-shale is the same as that prevailing in much of the lower parts of the shale at Dolgeville. We consider it therefore probable that the top of this section is equivalent to the lower part of the Dolgeville "Utica."

In a new road cut between Flat creek and Canajoharie about 340 feet above base of "Utica," hard and thin-bedded black shale was found, containing:

Climacograptus spiniferus (filling one bed)	(cc)
Leptobolus insignis	(c)
Triarthrus becki	(c)

Another road cut 40 feet higher and to the north of the former furnished again abundant:

Climacograptus spiniferus	(c)
Diplograptus vespertinus[2]	(cc)

This shale is very strikingly dark and light banded.

[1] *See* Paleontologic notes, p. 74.

[2] *See* Paleontologic notes, p. 83.

The heavy drift to the south has buried the "Utica" beds as far as the "Frankfort" beds at the base of the Helderberg escarpment.

If we combine the observations of Canajoharie and Flat creeks, we obtain the following groups of faunules, indicative of larger zones:

1 Zone of Diplograptus amplexicaulis, Corynoides calicularis, ostracods, lamellibranchs (notably Pterinea (Prolobella?) trentonensis and insueta, etc.).

2 Zone of Glossogr. quadrimucronatus cornutus, Corynoides calicularis, the ostracods, Cyathodictya, Triarthrus becki.

3 Zone of Lasiogr. eucharis, Lingula curta, Schizocrania filosa, Trocholites ammonius, Triarthrus becki.

4 Zone of Climacogr. spiniferus, Diplogr. vespertinus, Lasiogr. eucharis, Triarthrus becki

The first two zones have never, in our earlier work, been observed in the Dolgeville section, while the base of that latter section has furnished us a faunule identical with that of number 3. To be sure of the absence of the lower two zones in the Utica region, we have carefully searched the basal sections of the Utica at Dolgeville and Jacksonburgh, three miles west of Little Falls, where Cushing's map shows an exposure of the contact of Dolgeville (transition) beds and Utica shale; along the Starch Factory creek at Utica; and the exposure between Holland Patent and South Trenton, recorded by Miller. In none of these localities were any traces of the first two zones of the Canajoharie section found. On Nine Mile creek near South Trenton, where the contact of the Trenton and true Utica is exposed, Climacograptus typicalis is the dominant and characteristic graptolite of the basal Utica. This typical Utica graptolite occurs there in immense multitudes. It is associated with:

Mastigograptus simplex (*Walcott*)
M. tenuiramosus (*Walcott*)
Pleurograptus linearis (*Carruthers*)
Leptograptus annectans (*Walcott*)
Dicranograptus nicholsoni *Hopkinson*
Glossograptus quadrimucronatus (*Hall*), short, long spined variety
Cyathophycus reticulatus *Walcott*

This is the *characteristic fauna of the base of the typical Utica.* It is the Mastigograptus fauna of Schuchert (1910, p. 529). Lasiogr. eucharis appears in great numbers nearby (at Floyd and Marcy) and a little higher up.

In the Dolgeville and Jacksonburgh sections which lie halfway between Utica and Canajoharie, the base of the "Utica" shale (above the Dolgeville transition beds) shows no trace yet of the Canajoharie faunule, but contains:

Glossograptus quadrimucronatus
Climacograptus typicalis
Lasiograptus eucharis
Lingula curta
Schizocrania filosa

The dominant Climacograptus typicalis of the true Utica is found but sparingly, and Leptograptus annectans, Pleurograptus linearis, Dicranograptus nicholsoni and the Mastigograpti are not observed at all in the bed. It is therefore probable that the basal "Utica" at Dolgeville-Jacksonburgh and that at Utica do not represent the same horizons, and if so, the former is probably older than the latter.

From the assemblage of the facts here presented, we infer that at Canajoharie the two lower zones surely and the others most probably lie below the base of the true Utica and correspond in age to some part of the Trenton. For this older black shale of the Mohawk valley we propose the term *Canajoharie shale.* This stage is characterized by the following species:

Corynoides calicularis
Diplograptus amplexicaulis
Diplogr. (Mesogr.) mohawkensis
Glossograptus quadrimucronatus *var.* cornutus
Pterinea (Prolobella) trentonensis
P. insueta
Ulrichia? bivertex
Primitiella unicornis

All these are unknown to us from the Utica shale. A number of forms as Lasiogr. eucharis, Diplogr. putillus, Triarthrus becki, appear in the Canajoharie beds rarely, but become dominant forms in the Utica shale, and others, as the shale brachiopods Leptobolus insignis and Lingula curta, are equally common to both. The true Climaco-

graptus typicalis has not been seen in the Canajoharie beds, but is a most characteristic and common graptolite of the Utica beds.

A peculiar feature which we are at present unable to explain is the very frequent occurrence of Diplogr. (Mesogr.) mohawkensis in the Canajoharie beds in the Amsterdam sections and its apparent absence in the Canajoharie sections. Since it is not restricted there to the basal beds only, it can not be assumed that it represents still a lower horizon not represented at Canajoharie.

If the Canajoharie shale is older than the true Utica, it corresponds in age to some part of the Trenton. The question then arises, How much of the Trenton does it represent? The fossils of the underlying Trenton and transition shale at Canajoharie (see page 21) are those of the basal Trenton only, and this alone is represented by limestone in the lower Mohawk valley,[1] where it rests on the Amsterdam limestone. The lower Trenton, which is characterized by the Prasopora simulatrix zone and its base by the fauna of the Nematopora beds, is apparently at Canajoharie merged already in the Canajoharie formation, as the occurrence of a horizon with Prasopora simulatrix, rather high up in the Canajoharie beds in Flat Gulf (page 26) and the evidence of the bryozoan reefs at the base of the Canajoharie would indicate. The Canajoharie beds correspond therefore to at least the lower Trenton. What proportion, if any, of the middle Trenton is included can not be determined with the data at hand. The typical Canajoharie fauna at Canajoharie indicates as old Trenton as the oldest in the Trenton Falls section. Possibly it contains only lower Trenton but probably it belongs in large part between the lower and middle Trenton.

The true Utica is, from present evidence, entirely absent in the lower Mohawk region. We infer this from the faunas of the Canajoharie shale indicating Trenton age and further from the facts that these black shales pass gradually (as in the Minaville section) into the so called "Frankfort" or "Hudson River" shales and sandstones of the lower Mohawk valley and that these latter have proved to be of an age older than upper Trenton (see Schenectady formation, page 37).

[1] This conclusion had also been reached by Cumings (title 44, p. 466).

The writer has before cited faunules from the Hudson valley which contain the characteristic elements of the Canajoharie beds. The most important of these is that from the Rural Cemetery of Albany, whence Glossogr. quadrimucronatus mut. cornutus was described. It is there associated with

Mastigograptus circinalis *Rued.*
Corynoides calicularis *Nicholson*
Lasiograptus eucharis (*Hall*)
Diplogr. putillus (*Hall*)
Eopolychaetus albaniensis *Rued.*
Pontobdellopsis cometa *Rued.*
Leptobolus insignis *Hall*
Schizambon ? fissus *var.* canadensis *Ami*
Hormotoma *cf.* gracilis (*Hall*)[1]

This is one of the various upper subzones of the "Hudson River shales" which in the former publications (op. cit. page 36) we have referred to as an eastern development, characteristic of the Appalachian trough, of the Utica shale.

The belt of Canajoharie beds in the lower Mohawk valley is abruptly cut off by the Hoffmans Ferry fault which, since the eastern side has dropped, has buried all lower beds east of the fault, under a belt of "Frankfort" shales and sandstones extending from the town of Galway in the north across the Mohawk river to the foot of the Helderbergs. It becomes evident, however, from the facts cited above, that the Canajoharie beds reappear from under this thick mass of overlying "Frankfort" shales on the east, along the Hudson, through the Taconic-Green Mountain folding and they strike there according to this folding to the north-northeast, as indicated by the outcrops at the Rural cemetery and at Cohoes.

The stations which we had cited in Bulletin 42 as representing the Utica shale and forming a belt that passes through Albany, are now mostly to be considered as Canajoharie beds, the same as the occurrence at the Rural cemetery, and the few remaining like that at Black creek, Voorheesville and the Vly at Voorheesville (title 47, pages 531–33) are black shale zones intercalated in sandstones and correspond to the "Frankfort" rocks about Schenectady. We must infer from these facts that typical Utica is not represented in the Hudson River region but that the Canajoharie shale is directly followed by the "Frankfort" (Schenectady) beds.

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[1] *See* title 47, p. 528; title 60, p. 37.

This is, among others, suggested by an outcrop at Crescent, at the last bend of the Mohawk. At the latter place an anticline brings to the surface (thereby causing the rapids in the river) about 50 feet of "bluestone" (a calcareous sandstone) of the type characteristic of the "Frankfort" (Schenectady) beds, in beds 2–3 feet thick with intercalations of black shale. The latter, however, do not furnish the "Frankfort" faunule, noted in a later chapter, but

Corynoides calicularis *Nicholson*
Cf. Azygograptus ? simplex *Rued.*
Diplograptus putillus *Hall*
Climacograptus bicornis *Hall*
Diplograptus *cf.* angustifolius *Hall*
Leptograptus annectans *Walcott* (narrow form)

This congeries of forms contains on one hand the Corynoides on account of which we refer the beds to the Canajoharie formation, a reference which is supported by the close position of the outcrops to the belt of Canajoharie beds at the mouth of the Mohawk. It also contains Leptograptus annectans, a species that to our knowledge has been found hitherto only in the basal Utica beds in the neighborhood of Trenton, N. Y., and in the true Utica beds of Cincinnati (title 61, page 265) but the form representing this species at Crescent is not strictly the same as the typical Holland Patent type. The lithologic features of this interesting outcrop also indicate the fact that in the east, the upper portion of the Canajoharie formation may assume the lithologic character of the "Frankfort" (Schenectady) beds, a fact that would argue for a direct succession of the two formations in this region.

While the Canajoharie shale is eastward in the Mohawk valley cut off by the Hoffman's Fault, we have found it to reappear north of Schenectady along Alplaus creek and thence the black shales can be traced past Ballston Spa, Saratoga and along the edge of the Precambric to Glens Falls, where they are again cut out by faults. The locality on Alplaus[1] creek has afforded:

Corynoides calicularis
Glossograptus quadrimucronatus *mut.* cornutus
Lasiograptus eucharis
Leptobolus insignis
Orthoceras hudsonicum *nov.*[2]

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[1] A curious distortion of the old German locality name "Aalplatz," eel-place.

[2] This species retains in pyritized condition the protoconch and nepionic portion of the shell. See note, p. 113.

There can be no doubt of the Canajoharie age of the rock of this outcrop, and yet it is only two miles due north of the " Frankfort " outcrops of Rexford Flats, leaving but a narrow strip for a possible belt of intervening Utica shale; and considering the very slight southwest dip of the rocks also but little room for any thickness of the Utica shale.

Fine exposures of these Canajoharie shales were observed about Ballston Spa, especially along Kayaderosseras creek. Here occur:

Dicranograptus nicholsoni	(rr)
Glossograptus quadrimucronatus (in some beds large and typical)	(r)
Climacograptus spiniferus	(cc)
Lasiograptus eucharis	(r)

A similar faunule was observed on the Glowegee, northwest of Ballston Spa, while the single outcrop at Saratoga (Carlsbad Spring) contains:

Climacograptus spiniferus
C. mohawkensis
Lasiograptus eucharis
Leptobolus insignis

An excellent outcrop of the Canajoharie beds between Saratoga and Glens Falls is that at the falls of the Snook kill at Gansevoort, where occur:

Glossograptus quadrimucronatus *mut.* cornutus
Diplograptus mohawkensis
Lasiograptus eucharis

Very important exposures were found above and below Glens Falls. Those above are near the feeder dam, one to two miles southwest of the city and contain:

Corynoides calicularis
Diplograptus amplexicaulis
Glossograptus quadrimucronatus
Leptobolus insignis
Pontobdellopsis cometa
Orthoceras *nov. cf.* amplicameratum
Triarthrus becki

Between Glens Falls and Hudson Falls (formerly Sandy Hill) the contact between these shales and the basal Trenton limestone can be observed — or rather could be observed — the feeder dam between the paper mills and the mill races on both sides having

rendered inaccessible the contact exposed in the river bed. This contact was recorded by Mather (title 2, p. 394) as follows:

At a little distance below the ferry on the Saratoga shore, at and near the sawmill, the junction of the slate and Trenton limestone, and the gradation of one into the other by interstratification, with the numerous and beautiful fossils, which are intermingled near their junction, can easily be examined when the river is low. The trilobite, the Nuttainia concentrica of Eaton [Trinucleus concentricus (Eaton)], is extremely abundant, and on one specimen of a thin band of limestone six inches square, from the slate, were no less than ten of these trilobites, some of which were entire, and one of the Triarthrus becki.

While these transition beds can not be seen any more in place, the construction of the mill race for the Fenimore Paper Mill opposite Hudson Falls has brought to light a great quantity of the transitional rock which has been dumped along the river bank just above the mill. It consists of dirty grayish-brown limestone with black shale seams. The limestone is very fossiliferous; the following fossils have been noted:

Mesotrypa quebecensis (*Ami*)
Schizocrania filosa *Hall*
Dalmanella testudinaria (*Dalman*)
Plectambonites sericeus (*Sow.*)
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)
Isotelus fragments

The shales at the falls contain:

Corynoides gracilis *Hopkinson*
Diplograptus amplexicaulis *Hall*
Climacograptus spiniferus *Ruedemann*
Lasiograptus eucharis (*Hall*)
Trocholites ammonius *Conrad*

These shales can thence be followed about two miles through a fine gorge to the falls at Fort Edward, where there are found:

Corynoides calicularis *Nicholson*
Diplograptus *cf.* euglyphus *Lapworth*
Trematis terminalis (*Conrad*) ?
Orthoceras arcuolineatum *nov.*

From Fort Edward this belt of shale can be followed down the Hudson river for several miles. Occasionally, as in an outcrop two

miles south of the mouth of the Snook kill, limestone bands one to two inches thick appear, which are entirely composed of brachiopod, trilobite and crinoid fragments, but collecting will not furnish anything but the common brachiopods Dalmanella testudinaria, Rafinesquina, Plectambonites sericeus and the trilobite Trinucleus concentricus. The surrounding shales contain: Corynoides calicularis, Climacograptus spiniferus, C. putillus, Lasiograptus eucharis. The last mentioned form was also observed to fill a band of black shale about three miles up the Snook kill, where it is associated with Trocholites ammonius.

The following inferences in regard to this belt of black shales in Saratoga county seem of importance for the present inquiry:

1 These shales which have hitherto been considered as good typical Utica shales, are in their lithologic aspect like the latter but lack the strong calcareous admixture and for that reason rarely effervesce with acid. But, as we shall show later, they are lithologically quite distinct from the belt of Snake Hill beds, which adjoin them to the east, the latter containing not only numerous intercalations of grit and sandstone beds, as at Snake hill, but being also thinner bedded, more fissile, more argillaceous and less carbonaceous, approaching in their character the Frankfort shale.

2 The fauna of these shales is that of the Canajoharie beds of the Mohawk valley, as shown by the occurrence of and dominance of Corynoides calicularis, Diplograptus amplexicaulis, Glossograptus quadrimucronatus mut. cornutus, Lasiograptus eucharis.

3 These shales rest also in this belt on the basal Trenton (Glens Falls) limestone. This relation was observed, as above stated, at Hudson Falls. It may also be inferred from the outcrops on the Glowegee west of Saratoga, which lie but a short distance south and in the dip of the belt of basal Trenton (Glens Falls) limestone passing west of Saratoga through Rowland's mill and Rock City Falls.

FRANKFORT SHALE

The type locality of the Frankfort beds is the gorge of Moyer creek at Frankfort, about nine miles southeast of Utica. A parallel series of fine outcrops is furnished by Steels creek, only two miles away, in the so-called Ilion gulf.

Investigations of these two sections have shown that both lack the base or the contact with the Utica beds. A comparison with the sections of Starch Factory and Ferguson creeks near Utica indicates that the Frankfort and Ilion sections begin closely above the Utica shale. This is also evident from the fact that on the other side of the Frankfort section only two miles to the east, the Utica shale is still exposed on Fulmer creek south of the village of Mohawk. The strike of the shale in the latter outcrop will carry it to very near the base of the Frankfort and Ilion sections.

We found in the rock section at Frankfort which by aneroid is 305 feet thick,[1] four bands of shale containing fossils. The first of these was collected 15 feet above the base of the section at the foot of a cliff 60–70 feet high.

1 Climacograptus typicalis *Hall*
Lingula fragment
Leptobolus insignis *Hall*
Camarotoechia *sp.*
Orthoceras *sp.*
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)

The next fossiliferous band was found about 85 feet above the base at the second bridge over the creek. Here were obtained:

2 Climacograptus typicalis *Hall* (large specimens)
Prasopora *sp.* (minute colony)
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*) *mut.*
Rhynchotrema inaequivalve (*Castelnau*)
Modiolopsis *sp.* (fragment)
Orthoceras *sp.* (septum)
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)

[1] Since these beds dip toward the southwest with an angle that locally is ;°, but in general not more than 2°, it is obvious that this figure is too small. ushing (1905, p. 36) has determined the surface of the Beekmantown to all from Middleville to Ilion at a rate of somewhat over 100 feet a mile, tating that the line of greatest dip runs somewhat more to the westward of his direction. This line of greatest dip would then come near the direction f the Frankfort section and since a fall of 100° in a mile corresponds to ut 1° of dip, while the average dip in the Frankfort section appears to be erhaps twice as much, it is safe to assume that at least 200 feet should be dded, but probably a thickness of between 200 and 370 feet, the latter figure orresponding to a dip of 2°.

At about the same level is the black shale at the base of the Ilion section (230 feet below the Oneida conglomerate), which has furnished:

Climacograptus typicalis *Hall*
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*) *mut.* (small)
Dinorthis pectinella (*Emmons*)
Rhynchotrema inaequivalve (*Castelnau*)
Cf. Serpulites longissimus *Murchison*
Triarthrus becki *Green*

No fossils were observed until about 240 feet above the base, where occur:

3 Leptobolus insignis *Hall*
Orthoceras *sp.*

The last fossiliferous shales were found directly below the top (280–305 feet). They furnished:

Climacograptus typicalis *Hall* (c)
Orbiculoidea tenuistriata *Ulrich* (*fide Ulrich*)
Leptobolus insignis *Hall*
Orthoceras (fragment)
Triarthrus becki *Green*

Of these fossils the Orbiculoidea tenuistriata and the Triarthrus becki were found in the shale directly below the Oneida conglomerate.

It is obvious that these small faunules lack the essential elements of the Lorraine fauna and do not appear to consist of more than an impoverished Utica fauna. We see the strongest evidence of the close faunistic relation between the Utica and Frankfort periods in the uninterrupted persistence of Climacograptus typicalis through the whole of the Frankfort shales.

As it will be shown in the next chapter that the beds in the lower and probably middle Mohawk valley which have been hitherto referred to the Frankfort are of much older age, the Frankfort formation disappearing eastward by overlap and the relations of the typical Frankfort beds of the Frankfort section westward and northward have not yet been studied in detail, it becomes necessary to restrict for the present the term Frankfort shale to the formation as exposed in the Utica region. The formation thus restricted has its basal limit defined by the top of the true Utica, while the upper boundary, which in the Utica region is formed by the Oneida con-

glomerate, is not yet well defined in regard to the Pulaski formation, the question being to which of the two the shale with Trinucleus northwest of Utica is to be referred. Doctor Ulrich writes that he is inclined to place it with the Frankfort and to confine the Pulaski to the overlying even more fossiliferous arenaceous limestone and shale shown at Pulaski and in the upper part of the Lorraine gorge.

The problem of the correlation of the Frankfort formation, thus restricted and defined, with the strata of Ohio has been discussed very fully by Doctor Ulrich and the author. Doctor Ulrich recognizes in the Frankfort s. str. the two middle divisions of the Eden shale at Cincinnati, but he is convinced that it also includes the upper Eden. The Eden, as used by Doctor Ulrich for a long time, is confined to beds beginning at the top of the true Utica and extending upward to the base of the Maysville. But as originally defined the Eden included all the shales to the top of the underlying Point Pleasant Trenton limestone in the Ohio valley; hence it included also the thinning western representative of the true Utica. For this reason Doctor Ulrich has proposed to use the term Eden for a group comprising the Utica and Frankfort (title 69, plate 27). The Eden in Ohio is followed by the Maysville, which in New York is represented by the Pulaski formation and Oswego sandstone. The Lorraine, we infer from the above-cited chart, is retained as a local or New York term only to comprise the Frankfort and Pulaski formations.

SCHENECTADY FORMATION

As the black shale belt that follows the Mohawk river from Utica to near its mouth has always been considered as being of Utica age, but has been found to change in age from Utica to lower Trenton in descending the river, thus the parallel and coextensive belt of overlying, more argillaceous, olive gray shales has been quite naturally identified with the Frankfort shale by all authors, the present included, since these beds apparently form a continuous belt, just as the underlying black shale does. When we discovered in the great thickness of "Frankfort" beds in Schenectady and Schoharie counties the eurypterid fauna associated with a considerable number (see page 42) of graptolites, brachiopods, mollusks and trilobites, different from those of the Frankfort shale, we distinguished there several thousand feet of sandstones and shales as the "Schenectady facies" of the Frankfort formation. Closer investigation of the faunas, with the assistance of Doctor

Ulrich, has led to the conclusion that they are at least as old as upper Trenton and probably belong mainly between the middle and upper Trenton. We therefore propose to distinguish this formation as a separate unit under the term *Schenectady formation,* its type exposures being at the Dettbarn quarries at Schenectady and at Aqueduct and Rexford Flats near Schenectady.

The conclusion of an age older than the Utica for the Schenectady formation is supported by, or at once explains, the close connection by transitional beds of the Canajoharie beds (which are of lower to middle Trenton age) and these " Frankfort " beds of the lower Mohawk valley, as shown in the section about Minaville and along the Schoharie creek.

The Utica shale, if it continued down the Mohawk valley, would have to be found above the Schenectady beds. This inference is supported by the fact that the latter are overlain by the Indian Ladder shales (see page 50) which correspond in age to the Southgate of the Eden group and are but little younger than the true Utica.

If one follows the foot of the Helderberg escarpment from the typical exposures of the Frankfort shale down the Mohawk valley, one meets but few rather widely separated outcrops of the barren, olive gray Frankfort shales until one reaches the lower Mohawk valley region, where the rather abrupt widening of the belt and the thickening of the formation together with the appearance of much calcareous sandstone (bluestone) combine to change greatly the aspect of the " Frankfort " beds. The exact contact plane between the Frankfort shales that thin out eastward and the Schenectady beds that rapidly diminish westward, has not yet been established and may be entirely buried in the deep drift plateau between the foot of the Helderbergs and the Utica and Canajoharie exposures in the lower reaches of the southern affluents of the Mohawk.

The *thickness* of the Schenectady formation must be very great. Cumings (title 44, page 466) has already found in the hill back of Rotterdam a thickness of 1200 feet at least for the " Hudson River " beds, for the top of the formation is not there reached. That the thickness of the Schenectady formation is still considerably more, is proven by the Altamont well-boring. In that well, the drill started 595 feet below the top of the Indian Ladder beds and passed through 2880 feet of sandstone and shales before reaching the Trenton limestone. The shale formations have hence a total thickness of 3475 feet there. The lowest 1200 feet of this may be

Figure 2 Schenectady beds at Aqueduct, showing the alternating beds of sandstone ("bluestone") and shale

Figure 3 Nearer view of same quarry face to show irregular deposition of beds

attributed to the Canajoharie shale, since Cumings (op. cit. page 466) measured 950 to 1260 feet of black shales in the lower Mohawk region and 300 feet at least at the top belong to the Indian Ladder beds, a formation that follows the Schenectady beds in this region and will be discussed later (see page 50). There remain then 1800–2000 feet of Schenectady beds, since we properly assume that neither the Normanskill nor the Snake Hill beds reach as far west as Altamont. The Normanskill and Snake Hill beds extend considerably farther west than their original basin of deposition (see diagram, page 69) through extensive overthrusting which, however, has not reached the meridian of Altamont where the beds are undisturbed.

There are other lines of evidence which indicate a similar great thickness for the Schenectady shale and sandstone. One of these is the width of the belt of shales from Amsterdam to the Helderbergs which at the rate of 140 feet dip in a mile, observed for the Glens Falls limestone, corresponds to a thickness of 1925 feet of shale (13.75 miles by 140), to which must be added 900 feet representing the difference in height of the base of the shales at the north and their top in the south, subtracting from this 2825 feet again the 1140 feet found in that meridian for the Canajoharie shale, we obtain approximately 1700 feet for the Schenectady beds, the Indian Ladder beds having disappeared along the Schoharie creek section. The dips along the line Aqueduct to Schoharie, which are mostly southwest to west and amount to 1°–2°, frequently as much as 5°, as at Aqueduct, would also indicate a thickness of more than 2000 feet (2681 feet at 1° dip).

The cause of the astonishing thickness of the Schenectady shales is to be sought in their deposition in a basin, namely, the sinking foreland in front of the rising Green Mountain folds to the east; which basin was rapidly being filled with sediments. The shallow water origin of most of the shales and sandstones of the Schenectady beds is proven by the sun-cracks found in the thinner sandstones (as at the Bozen kill), the frequent layers of mud pebble beds,[1] cross striation with plunge structure, very rapid change of thickness of beds and other features.

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[1] These mud pebble layers occur mostly on top of the sandstone beds, when the latter are followed by argillaceous shales, indicating that the first clay deposits were rolled about by the waves upon the sand and formed into mud balls.

The rocks of the Schenectady formation contain a much greater amount of sandstone beds than the other shale formations of New York. Much of this sandstone occurs in thick banks, is somewhat calcareous and much quarried as "bluestone." The hundredfold alternation of these sandstone beds with the shales which persists to a more or less extent throughout the whole formation is the most notable lithic character of the eastern development. Numerous sections which show these endless alternations of sandstone which, on account of its often coarse nature, is cited as grit, with slate, have already been published by Mather in the First District Report (pages 375–79), from the lower Mohawk and from Schoharie county. We insert here as example a section which we have measured in the abandoned quarries and the river bank at Aqueduct and Rexford near Schenectady, in descending order:

1	Argillaceous shale	12′ =	12′
2	Grit banks, about 1 foot thick with shale intercalations ½ foot thick	9′ =	21′
3	Shale, argillaceous	14″ =	22′ 2″
4	Grit	3′ 6″ =	25′ 8″
5	Dark argillaceous shale	13′ =	38′ 8″
6	Grit	6″ =	39′ 2″
7	Shale	2′ =	41′ 2″
8	Compact grit	6′ =	47′ 2″
9	Shale	2′ =	49′ 2″
10	Calcareous grit ("bluestone")	2′ =	51′ 2″
11	Dark argillaceous shale	8′ =	59′ 2″
12	Grit bed	6″ =	59′ 8″
13	Dark shale, separated by fault from underlying beds	3′ =	62′ 8″
14	Grit	6″ =	63′ 2″
15	Shale, dark, argillaceous	2′ =	65′ 2″
16	Thin bedded grit	1′ 6″ =	66′ 8″
17	Bluestone	5′ =	71′ 8″
18	Shale	2′ =	73′ 8″
19	Bluestone	1′ 6″ =	75′ 2″
20	Thin alternating beds of grit and shale, banded and wavy	2′ =	77′ 2″
21	Compact beds of bluestone, with a few thin discontinuous shale seams. Beds irregular	9′ 6″ =	86′ 8″
22	Shale	4′ 6″ =	91′ 2″
23	Grit band with distinct plunge structure	6″ =	91′ 8″
24	Shale, dark, argillaceous	2′ 6″ =	94′ 2″
25	Grit bed with one shale seam	3′ 6″ =	97′ 8″
26	Shale, soft dark gray to black argillaceous and sandy shales	90′ + =	187′ 8″

The constant alternation of more or less coarse sandstone with shales is indicative of a frequent shifting of the conditions, presumably through currents, either reversal (tidal) or continuous currents. There is sometimes clear evidence of absolutely regular or rhythmic shifting. Such a place was for instance observed in an abandoned quarry on the Bozen kill between Altamont and Delanson. The base is here formed by a compact bed of sandstone some 15 feet thick. This sandstone is abruptly followed by dark argillaceous shale in which higher up thin sandstone layers appear, that become more frequent until another thick sandstone bed is formed, like the basal one. This in turn is cut off by a shale, that gradually yields to sand. The whole cycle is in this place repeated three times, shales and sandstones being each of equal thickness, the whole indicating a most remarkable regularity of change of deposition which on account of the very shallow water character of the rocks of that locality, may well have been a condition due to reversal or tide currents.

It agrees well with the evidence of the shallow water or shore origin of the Schenectady shales and sandstones, that they are often densely filled with remains of seaweeds (Sphenophycus latifolius Hall).

In contrast to the Frankfort shales the Schenectady beds have furnished a large fauna, although they had hitherto currently been held to be quite barren. Altogether about 70 species have been found and there appears to be no striking difference in the lower and upper faunas of this great mass of rocks, aside from that of the Indian Ladder beds, which have been separated as a distinct formation.

The following are the faunal lists from the principal localities.

The easternmost outcrops which represent very low beds of the formation are those at *Aqueduct* and *Rexford Flats*, three miles northeast of Schenectady; these have afforded the following association of species:

Sphenophycus latifolius (*Hall*)	(cc)
Azygograptus *sp. nov.*	(r)
Mastigograptus *cf.* simplex *Walcott* (fragment)	(rr)
Climacograptus typicalis *Hall*	(c)
Diplograptus vespertinus *Rued.*	(c)
Lingula rectilateralis *Emmons*	(rr)
Leptobolus insignis *Hall*	(c)
Rafinesquina alternata (*Conrad*) (small)	(c)
Serpulites	(rr)

Cyrtolites *sp.* (very young example)	(rr)
Trocholites ammonius *Conrad*	(r)
Cyrtoceras *sp. nov.*	(r)
Spyroceras bilineatum (*Hall*)	(rr)
Triarthrus becki (*Green*)	(r)
Isotelus *cf.* gigas *Dekay*[1]	(rr)
Primitia (minute form)	(cc)
Eurychilina	(r)
Pterygotus prolificus *Clarke & Ruedemann*	
P. nasutus *Clarke & Ruedemann*	

A much larger collection was obtained two miles farther southwest in the bluestone quarries at the northeastern outskirts of Schenectady, notably the Dettbarn quarry. This has afforded:

Sphenophycus (*Hall*)	(cc)
Mastigograptus *sp. nov.*	(r)
Climacograptus typicalis *Hall*	(cc)
Lasiograptus eucharis (*Hall*)	(c)
Crinoid joints	
Leptobolus insignis *Hall*	(c)
Lingula rectilateralis *Emmons*	(r)
Dalmanella testudinaria (*Dalm.*) (small)	(c)
Conularia trentonensis *Hall var.* multicosta *nov.*	(r)
Modiolopsis *cf.* modiolaris (*Conrad*)	(c)
Saffordia ulrichi *nov.*	(rr)
Cyrtoceras *sp. nov.*	(c)
Spyroceras *cf.* bilineatum (*Hall*)	(r)
Trocholites ammonius *Conrad* (small)	(r)
Triarthrus becki *Green*	(c)
Trinucleus concentricus *Eaton*	(rr)
Eurypterus pristinus *C. & R.*	(r)
E ? (Dolichopterus) stellatus *C. & R.*	(r)
Eusarcus triangulatus *C. & R.*	(c)
E ? longiceps *C. & R.*	(r)
Dolichopterus frankfortensis *C. & R.*	(r)
D. latifrons *C. & R.*	(r)
Hughmilleria magna *C. & R.*	(cc)
Pterygotus ? nasutus *C. & R.*	(r)
P. prolificus *C. & R.*	(c)
Stylonurus ? limbatus *C. & R.*	(c)

The next series of outcrops which, on account of the southwest dip of the beds, are probably a little higher in the Schenectady formation, are those at Rotterdam Junction. Prosser and Cumings have described (title 33, page 658) a small section nine-tenths of a

[1] This is a large complete individual 6.5 inches long, from the "bluestone."

mile west of the Schenectady pump station, from a deep glen and a long cut on the West Shore Railroad. This section is as follows:

			Feet
I	C 1	Covered from level of Mohawk river to Erie canal...........	25 = 25
	C 2	Fine shale which at the base of the glen does not weather readily to soil. Graptolites are fairly abundant	110 = 135
	C 3	Very fragile shale exposed in the railroad cut	12 = 147
	C 4	Thin sandstone layer	2/12 =
	C 5	Shale	1 5/12 = 148 7/12
	C 6	Thin layer of sandstone.........	
	C 7	Crumbling arenaceous shale	3 5/12 = 152
	C 8	Heavy layer of sandstone by the highway which runs under the railroad track east of the cut...	2 = 154

The following fossils are recorded "from a very thin layer of loose-grained, arenaceous shale exposed near the base of the railroad cut on both sides of the track and largely composed of the comminuted fragments of fossils":

1	Triarthrus becki *Green* Numerous small fragments of the pleurae and a few complete specimens of the glabella	(c)
2	Trinucleus concentricus *Eaton* Mostly fragments of the spines and cheeks	(c)
3	Plectambonites sericeus (*Sowb.*) *H. & C.* (?) All the specimens are very small and rather coarsely striated.	(c)
4	Dalmanella testudinaria (*Dalm.*)	(r)
5	Orbiculoidea *sp.*	
6	Monticulipora (Prasopora) lycoperdon *Say* (?)	(r)
7	Crinoid segments	(r)
8	Graptolites	

Cumings (title 44, page 45,) has later described a fine section exposed in a ravine on the northeastern slope of Waterstreet hill. This is as follows:

2 I Rotterdam section

l[1]	Near the railroad arch in the bottom of the creek 8 feet of very thin, fragile, dark grayish to bluish black, argillaceous shales with occasional very thin sandy layers, one near the middle of the stratum being about 1 inch thick.............	8′ = 8′

I^2	Heavy, compact sandstone of grayish to greenish blue color, weathering gray to brown........	10′ = 18′
I^3	Mainly grayish, friable shales with thin layers of sandstone..............................	12′ = 30′
I^4	Heavy sandstone with intercalated shale........	6′ = 36′
I^5	Dark crumbling shale........................	8′ = 44′
I^6	Shale with mainly thin, but some heavy layers of sandstone.............................	37′ = 81′
I^7	Heavy stratum of sandstone.....................	4′ = 85′
I^8	Shales with some thin layers of sandstone.......	15′ = 100′
I^9	Thick to thin and broken layers of sandstone....	10′ = 110′
I^{10}	Fine shale..............................	5′ = 115′
I^{11}	Thin broken sandstone with crumbling shale.....	45′ = 160′
I^{12}	Shale..................................	5′ = 165′
I^{13}	Thin sandstone and shale. Base of high waterfall.	5′ = 170′
I^{14}	Thin friable blackish shale by excavation of which from beneath the sandstone above, the fall has been formed..............................	12′ = 182′
I^{15}	Two layers of massive sandstone over which the water falls.............................	8′ = 190′
I^{16}	Thin sandstone layers........................	2′ = 192′
I^{17}	Clear dark shale............................	4′ = 196′
I^{18}	Apparently heavy-bedded sandstone weathering to thin often lenticular divisions...............	25′ = 221′
I^{19}	Shales and thin sandstones....................	10′ = 231′
I^{20}	Medium thick layers of sandstone with massive 2 foot layer at base and some thin beds of shale, and shaly partings.........................	39′ = 270′
I^{21}	Mostly covered. Highly inclined layers of sandstone exposed in the creek banks 120 feet above No. 20..................................	120′ = 390′
I^{22}	Covered to top of hill but with an occasional exposure of sandstone. 680 feet by barometer..	680′ = 1070′

We have carefully collected in this splendid section and found the following fossils:

In I^3	Climacograptus spiniferus *Ruedemann*	(c)
	Eurypterid fragments	
In I^6	Climacograptus spiniferus *Ruedemann*	(c)
	Leptobolus insignis *Hall*	(r)
	Eurypterid fragments	
In I^{11}	Sphenophycus latifolius (*Hall*)	(c)
In I^{13}	Eurypterid fragments	
In I^{15}	Sphenophycus latifolius (*Hall*)	
In I^{20}	Sphenophycus latifolus (*Hall*)	(cc)
	Callograptus multiramosus *nov.*	(rr)
	Rhytimya *sp.*	(rr)
	Eurypterus megalops *Clarke & Ruedemann*	(rr)

Eusarcus triangulatus *C. & R.*	(r)
Dolichopterus frankfortensis *C. & R.*	(c)
Hughmilleria magna *C. & R.*	(c)
Pterygotus prolificus *C. & R.*	(c)

In following the dip of the rocks, a long series of outcrops were found beginning at Duanesburg, about ten miles west-southwest from Schenectady, and extending about four miles along the railroad to Delanson. The dip is too small to measure accurately, different measurements giving from 1° to 2°, but it is safe to assume that these outcrops which are halfway between the lower beds at Schenectady and the top of the formation at the Helderbergs are 1000 feet above the base.

In a bluestone quarry just above the station at Duanesburg about 40 feet of thicker and thinner, partly coarser sandstone beds with intercalated gray, argillaceous and often also arenaceous shales are exposed. The sandstone beds are distinctly lenticular, rapidly thinning out and swelling up in the quarry face and carrying numerous mud pebbles near their surfaces. The shaly layers show fine cases of mud-flow and the whole character of the beds indicates a rather shallow, current or wave-swept sea. The shale seams are profusely filled with seaweeds and fragments of eurypterids.

The following species were obtained:

Sphenophycus latifolius (*Hall*)	(cc)
Climacograptus bicornis *Hall*	(r)
Camarotoechia *sp. fragments*	
Dolichopterus frankfortensis *Clarke & Rued.*	(c)
Eusarcus triangulatus *C. & R.*	(c)
Stylonurus ? limbatus *C. & R.*	(r)
Hughmilleria magna *C. & R.*	(c)
Pterygotus prolificus *C. & R.*	(c)
P. ? nasutus *C. & R.*	(r)

The beds can be followed along the Schenectady branch of the Delaware & Hudson Railroad in a continuous exposure to Delanson, without any change in lithic or faunal character. Following then the southwest dip no outcrops are met with until the Schoharie valley is reached, where a number of small exposures are observed in the river bank above Schoharie Junction. These represent the uppermost portion of the Schenectady beds and can not be more than 300 feet below the top, or the boundary with the Brayman shales in the hills to the east and west of the valley. The beds are still the same alternating thick impure sandstones and dark gray to

black shales. It is, however, obvious that the sandstones have become more silicious and are prevailingly gritty, often coarse and assuming the character of an arkose, as notably at Duanesburg. The top layer of the sandstones frequently contains numerous mud pebbles inclosed in the sandstone.

The following fossils were collected along Schoharie creek:

Sphenophycus latifolius (*Hall*[1])	(r)
Climacograptus typicalis *Hall*	(c)
Taeniaster schohariae *nov.*	(rr)
Conularia trentonensis *Hall var.* multicosta *nov.*	(rr)
Eurypterida: Dolichopterus frankfortensis; Pterygotus *sp.*	

While in the Schoharie valley the Schenectady beds can not be followed to their contact with the overlying Brayman shales, this can be done along a small northern branch of the Cobleskill between Central Bridge and Howes Cave, which has been pointed out by Grabau (title 56, page 102) as an excellent exposure of the Brayman shales. Here about 120 feet of Schenectady shales and sandstones are exposed in the ravine above and below the road. The lower portion consists prevailingly of dark gray to brownish green, sandy shales with black argillaceous shales in thinner seams. These change upward into purely sandy shales, which grade into a sandstone about 20 feet thick that is followed by the Brayman shale. The lower shales furnished great quantities of Sphenophycus latifolius and many fragments of eurypterids, among these chelicerae of Pterygotus, and carapaces of Pterygotus prolificus, Eurypterus pristinus, Dolichopterus cf. frankfortensis and Hughmilleria cf. magna. These eurypterid remains could be traced into the bottom of the topmost sandstone bed. Thus we see that here the eurypterid fauna indicative of the Schenectady formation reaches close to the Brayman shales which are supposed to be of Upper Siluric age (see postea page 54).

Another series of outcrops of the middle and lower Schenectady formation is found along the Schoharie creek from Central Bridge

[1] This is the type locality of the species. Hall states of the occurrence of the latter: "This species occurs in considerable abundance near Schoharie, in the bed of the creek, in the central part of the Hudson River group. I have not seen it in any other locality." We have not been able to find Gebhard's old locality at Schoharie, but as is seen from the lists, have observed this remarkable seaweed in sometimes immense quantities in other outcrops, as at Kellum's quarry near Schenectady and in the Rotterdam Junction section.

to Fort Hunter, at the mouth of the creek. About seven and one-half miles south of Fort Hunter the contact of the Canajoharie shale with the Schenectady is a very distinct one. The section at this contact in a cliff on the western side of the creek, three miles south of Mill Point, has been described by Prosser (1900, page 470), as follows:

		Feet
45X[1]	Clear black shale from the water to the base of lowest sandstone stratum in the cliff, 114′ by level and 105′ by barometer. At the sandstone stratum there is a decided lithologic break from the black argillaceous shales below. Utica shale........................	114 = 114
X[2]	Grayish sandstones alternating with bluish argillaceous shales to the top of the cliff. Hudson River formation..................	195 = 309
X[3]	Mostly covered from the top of the cliff to the highway	15 = 324
X[4]	Occasional ledges of sandstone show on the side of the hill from the highway nearly to its top. Hudson River formation..........	120 = 444

From this point up the river a splendid series of exposures of the Schenectady formation is furnished by the river banks. The section from Burtonville (formerly Burton's bridge) to Esperance has already been described in detail by Mather (title 2, page 379). Hundreds of feet of rock are here exposed in magnificent cliffs; on investigation they prove, however, a monotonous alternation of sandstone or grit beds with shales with an extreme scarcity of fossils. As far as fossils were observed (a few traces of Climacogr. typicalis in the upper layers and Sphenophycus latifolius in the lower shales), they show the great uniformity of the fossil content throughout the entire series of beds here comprised as Schenectady shale.

A third group of fossiliferous outcrops has been observed by us five to ten miles south of Schenectady, directly in front of the Helderbergs, along the Normanskill and its branches, the Bozen kill and the Vly near the villages of Altamont, Guilderland and Voorheesville. We have already described on page 41 the remarkable alternation of sandstones and shales at the Bozen kill. Continuous outcrops ranging through 200 and 300 feet of rock are found in the upper branches of this kill west of Altamont, which form deep ravines in the lower slope of the Helderberg escarpment. These beds consist prevailingly of bluish and greenish gray shales with several intercalations of sandstone beds, the latter reaching

15 feet in thickness. The beds are nearly barren; only a few fragments of eurypterids were found in the lowest portion. More fossiliferous proved the excellent exposures along the Vly beginning at the fall a mile below Voorheesville. These beds are from 500–600 feet or more from the base of the Upper Siluric beds (Manlius waterlime) of the Helderbergs. The beds of that section are at the western edge of the Appalachian folds of the slate belt of New York and still slightly disturbed by small folds and some overthrusts of probably small throw. The upper beds of this section, which comprises about 200 feet, consist of fossiliferous black to grayish argillaceous shales with several sandstone intercalations and the lower beds of black shales with but few and thin sandstone beds. These shales, of which 80 feet are exposed in the steep eastern bluff of the creek, were formerly referred by the writer (title 47, page 532) on account of their lithic character and fossil contents to the Utica shale. We have now a much larger fauna from this section at our disposal which, with our present knowledge of the shale faunas, throws a different light upon the question of the age of these shales. The latter contain:

Diplograptus vespertinus *Rued.*	(c)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Climacograptus typicalis *Hall*	(c)
Leptobolus insignis *Hall*	(r)
Minute individuals of Rafinesquina	
Pterinea (Prolobella) trentonensis *Conrad*	(r)
Orthoceras *sp. nov.* ("Endoceras proteiforme")	(c)
Lepidocoleus jamesi *H. & W.*	(r)
Primitia *sp.*	

The sandstone layers of the upper portion have furnished:

Climacograptus typicalis *Hall*	(c)
Hughmilleria *cf.* magna *C. & R.*	(r)

An excellent section leads from these beds up to the Upper Siluric along a branch of Black creek at the Indian Ladder. The beds here exposed have furnished a different fauna and are described further on (p. 50) as Indian Ladder beds.

The combined faunal list of the Schenectady formation is:

Sphenophycus latifolius (*Hall*)
Dictyonema multiramosum *nov.*
Azygograptus *sp. nov.*
Mastigograptus *nov. cf.* simplex *Walcott*
M. *sp. nov.*

Figure 4 Bega's cliff on Schoharie creek. Canajoharie shale at base; Schenectady beds above.

Diplograptus vespertinus *Rued.*
Climacograptus bicornis *mut.* ultima *nov.*
C. typicalis *Hall*
Lasiograptus eucharis (*Hall*)
Crinoid joints
Taeniaster schohariae *nov.*
Lingula rectilateralis *Emmons*
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*)
Rafinesquina ulrichi *James* (typical)
Plectorthis plicatella *Hall*
Orbiculoidea *sp.*
Conularia trentonensis *Hall var.* multicosta *nov.*
Serpulites *sp.*
Saffordia ulrichi *nov.*
Cyrtolites *cf.* ornatus *Conrad*
Cyrtoceras *sp. nov.*
Spyroceras bilineatum (*Hall*)
Trocholites ammonius *Conrad*
Triarthrus becki (*Green*)
Isotelus gigas *Dekay*
Trinucleus concentricus *Eaton*
Primitia
Eurychilina *cf.* subrotunda *Ulrich*
Eurypterus pristinus *Clarke & Ruedemann* [1]
E. megalops *C. & R.*
E ? (Dolichopterus?) stellatus *C. & R.*
Eusarcus triangulatus *C. & R.*
E ? longiceps *C. & R.*
Dolichopterus frankfortensis *C. & R.*
D. latifrons *C. & R.*
Hughmilleria magna *C. & R.*
Pterygotus nasutus *C. & R.*
Stylonurus ? limbatus *C. & R.*

The dominant elements of this large fauna are certain Canajoharie and Utica shale species on one hand, and the eurypterids on the other. The former elements are the species of Mastigograptus, Diplograptus vespertinus, Climacograptus typicalis, Lasiograptus eucharis, Leptobolus insignis, Trocholites ammonius[2]

[1] The eurypterids are described and figured in the forthcoming Memoir on the Eurypterida of New York by Clarke and Ruedemann.

[2] Trocholites ammonius Hall is a form that probably occurs entirely or mainly below the Utica in the Canajoharie shale. Its type localities (title 3, p. 309) are the East Canada creek, Canajoharie and Coldspring, all three localities of shales older than the Utica.

and Triarthrus becki. These are also the most frequent species, and the entire fauna receives thereby a distinct Canajoharie-Utica aspect. But we also note in the congeries of forms a number of species that are not observed in either the Canajoharie or the Utica, but are known only from the Trenton. Such species are Lingula rectilateralis, Conularia trentonensis, Spyroceras bilineatum, Trinucleus concentricus, Eurychilina. It is mainly the evidence from these fossils that indicates the Trenton age of the Schenectady formation. Finally there is a strong element of entirely new species, giving the Schenectady beds a distinct character of its own; this element consists of a few rare species, as Dictyonema multiramosum, Taeniaster schohariae, Saffordia ulrichi, and especially of the eurypterids. It is true the Echinognathus clevelandi Walcott, of the Utica shale of Holland Patent, N. Y., may be contained in this Schenectady fauna, and thus also one eurypterid at least be a Utica element, but there is still no doubt that the eurypterids of the Schenectady beds constitute a strong distinctive feature from the Utica fauna as known to us at present.

If we attempt to compare this formation with others outside the State, we find similar shale beds of upper Trenton age in the lower third of the Martinsburg shale (title 62, page 62) in Pennsylvania, extending thence probably into the Martinsburg shale of New Jersey and south into Maryland.

INDIAN LADDER BEDS

The best section known to us leading from the Schenectady beds up to the Upper Siluric beds, is along the upper left branch of Black creek forming the fall and deep ravine at the Indian Ladder near Meadowdale, Albany county, N. Y. The section comprises about 410 feet (aneroid measurement), of which the lowest 100 feet are dark gray to black argillaceous shales with two thick sandstone bands (each about 4 feet), while the next 100 feet are of a character not met with in other outcrops of the Schenectady beds. They consist of rapidly alternating dark gray shales and thin rusty looking, somewhat calcareous sandstone layers, ½ to 1 inch or more thick. The uppermost part of this portion becomes quite sandy. Nearly 100 feet are there covered, while some 120 feet at the top consist of prevailingly heavy sandstone beds with intercalated dark arenaceous and argillaceous shales, and an occasional

thin limestone band. The top is formed by a white hard sandstone bank 3½ feet thick and consisting largely of rounded sand grains. This is separated by shale, one layer of which consists of pyrite, from an underlying gray sandstone bed, also composed of rounded grains. The sandstone beds of this upper part of the formation are extremely irregular courses; in one case a bed was seen to run out within 10 feet from 4 feet to ½ foot.

These beds present an extremely barren aspect; the only observation of fossils in them of which we are aware is that by Walcott (title 17, page 345) who states: "The only fossils I found at this locality were Orthis testudinaria and Trinucleus concentricus." Very thorough search has furnished us a small graptolite faunule in the shales of the lower 200 feet and another faunule in the thin calcareous sandstone intercalations of the second hundred feet. A few bands of the latter proved to be covered with the remains of a microfauna, especially small crinoid joints.

The shale has furnished:

Dictyonema arbuscula *Ulrich*	(r)
Diplograptus peosta *Hall*	(r)
Dicranograptus nicholsoni *Hopkinson* (typical)	(rr)

The sandstone contains a pronounced microfauna which has been kindly determined for us by Doctor Ulrich as follows:

1	Columns and calyx plates of a cystid allied to Cheirocrinus	(r)
2	Very pentagonal columns	
3	Small Heterocrinus columns	(cc)
4	Callopora nealli (*James*) *Ulrich*	
5	Arthrostylus tenuis *Ulrich*	
6	Helopora *n. sp.*	
7	Rhinidictya *cf.* parallela (*James*)	
8	Rafinesquina ulrichi (*James*)	(cc)
9	Plectambonites *nov.* (= centricarinatus *nov.*)	(c)
10	P. plicatellus (*Ulrich*)	
11	Dalmanella multisecta (*Meek*)	(c)
12	Lepidocoleus jamesi (*Hall & Whitfield*)	(c)
13	Ceratopsis chambersi (*Miller*) (typical)	(c)
14	Trinucleus bellulus *Ulrich*	(c)
15	Acidaspis crossota *Locke*	(c)
16	Calymmene (Cincinnati Eden species)	

We also had a Tentaculites cf. flexuosa Hall, a small Hyolithes, fragments of Ceraurus pleurexan-

themus Hall and small cranidia of a Dalmanites (Pterygometopus).

Doctor Ulrich has determined the horizon as corresponding to the lower third of the Southgate shale of the Eden group at Cincinnati.

A comparison of the fossil list here given with that of the Schenectady beds shows at once that the "Frankfort" beds of the lower Mohawk valley contain two distinct faunas. The beds at the Indian Ladder also differ in their lithologic aspect; it is therefore safe to distinguish them as a separate unit, for which the name *Indian Ladder* beds is here proposed.

The Indian Ladder fauna is markedly distinct from the Schenectady fauna in the absence of all the dominant forms of the latter, as notably the eurypterids, Climacograptus typicalis, Triarthrus becki, Trocholites ammonius and the seaweeds. It consists on the other hand of a congeries that has hardly any members in common with the Schenectady beds. Much of this is clearly due to a different facies or different marine conditions, at least in the contents of the rusty limestone bands; for instead of the mud-loving linguloids and lamellibranchs of the Schenectady beds, we find here the strophomenoids and orthoids, indicating clearer water. The novel element of this faunule is represented principally by bryozoans, brachiopods, the ostracod Ceratopsis chambersi and the trilobites (Acidapsis crossota, Trinucleus bellulus) and the reappearance of such Trenton forms as Dalmanites callicephalus and Ceraurus pleurexanthemus. Also the graptolite faunule of the shale is totally different from that of the Schenectady beds. In Dicranograptus nicholsoni it contains an upper Trenton and lower Utica element, that here reappears after a long interval, in Diplograptus peosta, the first forerunner of the Lorraine fauna and in Dictyonema arbuscula, a form of the middle Eden shale of Ohio. The combined evidence of the whole fauna is that the Indian Ladder beds are younger than the Schenectady beds, not a mere different facies of the same, but still older than the typical Lorraine.

The horizontal extension of the Indian Ladder beds in the exposures at the base of the Helderberg escarpment seems to be but very restricted. In the section obtained along the roads south of Altamont, only four miles west of the Indian Ladder,

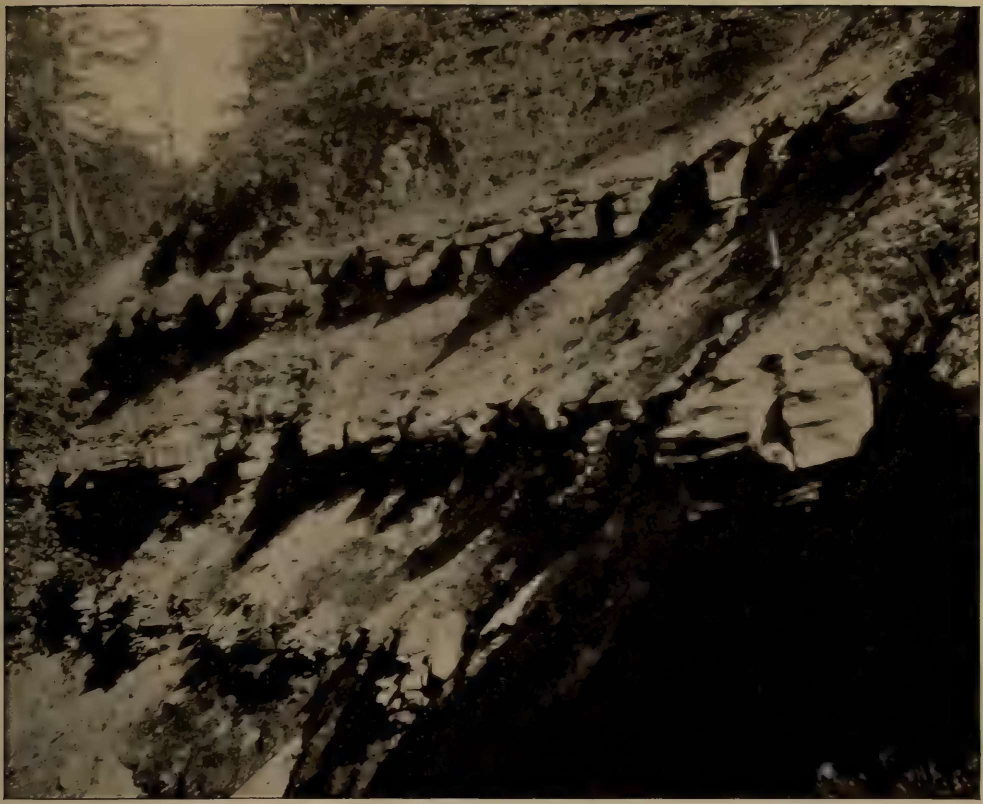

Figure 5 Upper part of type exposure of Indian Ladder beds at the Indian Ladder, showing the alternating shale and thin fossiliferous limestone beds

Figure 6 Lower part of the same exposure, showing the thick-bedded sandstone with shale alternations

S p h e n o p h y c u s l a t i f o l i u s was observed only 180 feet below the Manlius limestone. Since we have not observed this fossil in the Indian Ladder beds and consider it as characterizing the Schenectady formation, it would follow that the Indian Ladder beds are here already reduced to less than 200 feet in thickness. The orange colored rusty limestone bands of the lower Indian Ladder formation were in this section observed at several places above the Sphenophycus beds.

Westward between Altamont and Schoharie the uppermost part of the Lower Siluric is nearly everywhere found buried under drift. In the road-ditch halfway between East and West Township the characteristic orange colored limestone was observed only 10 feet below a ledge of Manlius limestone.

To the east of the Indian Ladder the only opportunity for the observation of the Indian Ladder beds is afforded by the New Salem sections described by Prosser and Rowe (title 34, page 334). The authors describe there two sections, one the Countryman Hill section, and another south of New Salem. In the former section 57 feet of " bluish gray, fairly massive sandstones which alternate with dark colored argillaceous shales," are cited as representing the Lower Siluric. These are separated by a covered interval of 10 feet from the Manlius limestone. In the other section, which is but half a mile to the east, the contact between the Lower Siluric and the overlying beds is shown. Prosser and Rowe describe the lower part of the sections as follows (op. cit. page 338):

	Feet
B4 Thin bedded dark blue limestone. *Tentaculite limestone*	32 1/2
B3 Drab, impure limestone, well exposed in the run at the foot of the cliff. *Waterlime*.	6 1/2
B2 Greenish sandstone to coarse arenaceous shale containing plenty of iron pyrites, 10 inches in thickness. Possibly it represents the attenuated Clinton formation.	1/2
B1 Dark blue to olive tinted argillaceous shales well exposed in the steep banks of the brook. *Hudson River shales*.	90

A third outcrop of the Lower Siluric shales is found between these two in the culvert and ravine just south of New Salem at the new State road. Here about 20 feet of dark shales with a few sandy layers are exposed, which extend within 15 feet from the Manlius (Tentaculite) limestone.

None of these three localities has furnished the writer any fossils save a few small crinoid joints in the last mentioned; hence the fossil evidence leaves the question of the correlation of these beds open. The absence of the Sphenophycus latifolius, of fragments of eurypterids and Climacograptus typicalis would, however, indicate that these beds belong to the Indian Ladder beds which for the greater part are entirely barren. Lithologically they also lack the orange colored rusty thin limestone bands which characterize the lower portion of the Indian Ladder section. It is, however, quite apparent that the New Salem sections do not reach far enough down into the Indian Ladder beds to expose these fossiliferous bands. The beds of the Countryman Hill section correspond to the upper beds of the Indian Ladder section.

A noteworthy feature of the two sections of the Lower Siluric beds at New Salem is the horizontal change from the prevailing thick sandstone beds of the Countryman Hill section to the dark shales of the other sections in the astonishingly short distance of less than half a mile.

Brayman shales

The status of the Brayman shales has been lucidly brought up to date by Grabau (title 56, page 101). He says:

These with the exception of the basal sandstones, are the only beds of the Salina period occurring in this region. They have been variously described in the literature as Clinton shales, pyritiferous shales, Salina shales, etc. The name Brayman shales is chosen for them from the village of Braymanville on the Cobleskill, between which place and Howes Cave they are well exposed. As the shales have so far proved unfossiliferous their exact equivalency is somewhat uncertain. From their position immediately below the Cobleskill limestone it may be confidently inferred that they are of Salina age, but whether they represent the Bertie waterlime of Buffalo, which is the immediate predecessor of the Cobleskill of that region, or whether they are of somewhat earlier age is a question difficult to determine. That there is a slight hiatus between the Brayman shales and the Cobleskill seems to be indicated by the fact that the upper bed of these shales is somewhat conglomeratic, with rounded or elongate pebbles of clay shale inclosed in a dark matrix, partly a calcareous sand and containing numerous scattered, rounded quartz grains. This indication of wave activity at the end of deposition of the Brayman shales and the want of transitional beds between the clay shale and the lime sandrock (Cobleskill) suggest that there is a short time interval unrepresented. This fact, together with the

distinctive character and local development of these shales, demands their description under a separate name, as a local member of the Salina series of deposits, whose exact equivalent in the complete Salina series of Central New York is doubtful.

The main mass of the Brayman shale is an olive or grayish clay rock often alternating with bluish beds and weathering to a lighter color, and having the appearance of a solid mudbank. Concretions of iron pyrites are very abundant and of all sizes, though generally not much larger than a man's fist. The pyrite is commonly an aggregate of crystals, often of considerable size, the cube and pyritohedron being about equally represented. Exposed portions rapidly oxidize changing to an ochery color, and commonly stain the adjoining shales. As already noted, no fossils have yet been found in this formation.

Near Mix and O'Reilly's quarry northeast of Schoharie, Hartnagel's measurement showed 27 feet of these shales. This gives a decrease of 13 feet in a distance of 5 miles. At this point, near the crusher, the contact with the underlying sandstone is well exposed, the two series of strata being absolutely conformable. The surface of the sandstone, exposed for several hundred yards, appears to be a perfectly normal deposition surface, and no trace of erosion, such as we might expect if there was an interval covering Lower and Middle Siluric time, is visible. Moreover the sandstone is pyritiferous like the shale, and no fragments of the lower rock are found in the Brayman shales. Neither does the surface of the top sandstone layer show traces of weathering before the deposition of the Brayman shales.

It is inconceivable that the surface of this sandstone even if worn down to a uniform stratum, should be swept absolutely clean before the shales were deposited, so that no fragments of sandstone are found in the shale. It is clear that all the facts point to the intimate relationship between the upper beds of sandstone and the Brayman shales, making these sandstones of Upper Siluric (Salina) age. The unconformable contact between these sandstones and the Champlainic beds (Lorraine) must be looked for some distance down in the sandstone series.

The most easterly extension of the Brayman shales, so far as has been observed, is according to Hartnagel . . . near Gallupville, 5 miles east of Schoharie, showing that the extreme eastern extension of the great Salina beds of New York can not be far from the town of Knox, Albany county, at which place it is quite likely that the Cobleskill slightly overlaps the Salina. Both of these formations are absent at Altamont, a few miles farther east, and the Rondout is seen resting directly on the Lorraine beds.

The age of the shales here considered has been variously judged. The name pyritous or pyritiferous shales was applied to this formation by the early geologists, and since it occurred below the Coralline or Cobleskill limestone, which was regarded as of Niagara age, and above the Shawangunk grit, which was supposed to be the

equivalent of the Oneida conglomerate of central New York, its age was assumed to be Clinton. Recent investigations by Ulrich and Schuchert,[1] and by Hartnagel, have shown that the formation in question is of late Siluric age, the former authors regarding it as a part of the Cobleskill and including it within the Manlius series, while Hartnagel, Clarke and others regard it of Salina age. As will be shown presently, it is probably the partial equivalent of the lower cement bed of Rosendale which in turn represents a part, but probably not a whole, of the Bertie waterlime series of western New York.

It is seen from this discussion that the Brayman shales rapidly disappear eastward and that they have been correlated with the Salina on account of their position below the Cobleskill limestone. Grabau has argued that the Brayman is more closely united with the underlying sandstone of the " Lorraine " beds than with the overlying Cobleskill limestone. For that reason, he would transfer these sandstones into the Upper Siluric (Salina) age,[2] expecting to find the unconformable contact with the " Lorraine " beds below them. We have, however, pointed out in the description of the Central Bridge section, that the eurypterids of the Schenectady shale continue into the lower part of this sandstone, and that the sandstone beds of the top of the Schenectady shale in that section are also united with the Brayman shale by their pyrite nodules, exactly as in Mix and O'Reilly's quarry at Schoharie (Grabau, page 103). One would, from this evidence, rather infer that the top sandstone of the " Lorraine " (Schenectady) shale, by its close relationship to the Brayman shale, draws the latter into the Lower Siluric. No fossils have been found in the Brayman shale and the formation has not been directly traced eastward or westward into another formation, thereby revealing its true age by direct evidence.

We have therefore in the correlation of these shales to rely for the present entirely on indirect evidence.

In the attempt to trace the shale eastward along the foot of the Helderberg escarpment outcrops fail outside the Schoharie recess in the escarpment until the Indian Ladder and the New Salem sections are reached, where 10 inches of " greenish sandstone to coarse

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[1] Ulrich and Schuchert, in their " Seas and Barriers," accepted merely previous determinations. R.

[2] Grabau follows here merely the general though unfounded assumption of the Salina age of the Brayman shale. Assuming that the sandstone is of Ordovicic age, the same line of arguments would show the Brayman shale to be of Ordovicic and not of Salina age.

arenaceous shale containing plenty of iron pyrite" is found between the top of the Indian Ladder beds and the waterlime. This bed corresponds in its lithic character and aspect, position and especially also in the strong pyrite content so much to the Brayman shale, that it is a fair inference to consider it as the last eastern trace of the formation.[1] It is here as sharply separated from the overlying waterlime (Rondout waterlime), as it is from the Cobleskill beds at Schoharie and it is likewise sharply separated from the underlying Indian Ladder beds.

Extending so far east beyond the Cobleskill limestone, it is noncontiguous with the latter and independent from it; but it is also to be noted that the bed overlies both the Schenectady shale (at Schoharie) and the Indian Ladder beds at the Indian Ladder, which would seem to make it independent from the Schenectady shale.

Westward from the typical outcrops of the Brayman shale in the Helderberg recesses of the Schoharie creek and Cobleskill, we are not aware of any other outcrops but that at Sharon Springs exposing the contact of the "Frankfort" shale with the overlying beds. At Sharon Springs, both Mr Hartnagel and the writer have noted that the basal beds of the waterlime (corresponding to either the Bertie waterlime or the Camillus) are largely composed of greenish, olive and bluish clay shale resembling the Brayman shale, but lacking the pyrites, and apparently passing by gradation into the typical waterlime. The inference would be that in this locality, which is 10 miles northeast of the Central Bridge outcrop, where the Brayman shale is 27 feet thick, the Brayman shale is merged into the lower Salina beds and this is probably the most potent argument that can be brought forward for a correlation of the Brayman shale with the Salina beds, especially since the thickness of the waterlime at Sharon Springs (about 30 feet) roughly corresponds to that of the Brayman shale at Brayman and Central Bridge.

But the absence of the pyrite in the basal waterlime at Sharon Springs and the restriction of the bluish shales to the base would suggest that we here have possibly reworked Brayman shales before us.

Mr Hartnagel has observed that most formations overlying the Frankfort shales are charged with the iron pyrite at their base, as

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[1] Harris (Bull. Am. Pal. no. 19, p. 25) has indeed compared the bed with the Brayman shale, while Grabau (title, p. 292) considers it as the "basal clastic beds of the Rondout."

the Oneida conglomerate in the Frankfort section. It then is probable that the Frankfort shale is the source of this pyrite and that the pyritiferous layer capping the Frankfort, Schenectady and Indian Ladder beds is a residual clay representing the long hiatus that corresponds to the remainder of the Ordovicic and the greater part of the Siluric. The thickness of the Brayman shale, its lithic character and overlapping distribution argue in favor of its residual origin. In that case the presence of the pyrite in both the Brayman shale and the top sandstone of the Schenectady shale would lose its force as a connective of the two formations and the exact age determination of the shale again becomes impossible from that criterion.

But the facts remain that the Brayman shale, where it is thickest and typically exposed, rests upon Schenectady beds, or beds as old as the upper Trenton age and that there is apparently, as pointed out by Grabau, no erosion interval observable between the top sandstone of these Schenectady beds and the Brayman shale; and the conclusion is hence permissible that the Brayman shale should be correlated with some part of the Upper Ordovicic (i. e., the Cincinnatian) rather than the Salina. My correspondence has shown that Doctor Ulrich and the author had reached the same conclusion independently at their separate visits to the Schoharie region, and Doctor Ulrich has in the Revision of the Paleozoic Systems correlated the Brayman shale with the Frankfort (title 69, plate 27).

Snake Hill beds

The separation of the Canajoharie beds from the Utica formation necessitates the recognition and definition of a further unit in the slate belt of the upper Hudson River region. A large fauna had been collected from these beds by the author about the mouth of the Mohawk river and published in 1901 in New York State Museum Bulletin 42. The principal localities were the east and north shores of Green island, Van Schaick island, Block island, Mechanicville, and Brothers' quarry at Troy. On the strength of these faunules the shales had been referred to the lower and middle Trenton (Watervliet, Port Schuyler), Utica and Lorraine. In Memoir 11, page 29, this belt of shale has, on the evidence from the graptolites, been correlated with the upper Trenton and the name Magog shale from the graptolite locality Magog in Quebec applied to it. Investigations since carried on in this slate belt about Saratoga lake have furnished a large addition to the fauna hitherto

known; and by the relations of the beds to the Canajoharie shale and the new fossils discovered the inference of the Trenton age of these shales has been much strengthened.

While we have little doubt of the approximate equivalency of the Magog shale with this shale of the Hudson valley, the fact that the former contains only a graptolite fauna, while the shale in the Hudson valley carries a mollusk fauna and that but few graptolites are common to the shale in Quebec and that on the Hudson, suggests that in the present state of our knowledge, at least, it is more appropriate to distinguish the two terranes by different names, especially also since we do not know whether the two are continuous and deposits of the same basin. Our reason for identifying the two shales was the occurrence in both of certain graptolites, notably Climacograptus caudatus, C. scharenbergi, Cryptograptus tricornis and species of Corynoides. All these are, however, European species which very well might have entered the different channels in the Appalachian system of troughs from the Atlantic basin to the east, as for instance through the St Lawrence region and the New Jersey inlet.

On account of the large faunas obtained on Snake hill on the east shore of Saratoga lake we will designate these shales as *Snake Hill shales*. Their lithologic character and their section on the east shore of Saratoga lake will be fully described in the Schuylerville quadrangle to be published together with the Saratoga quadrangle by Professor H. P. Cushing and the writer.

A large list of fossils were recorded from this formation in a former publication (title 47), but this original list needs revision, since a great many of the species had been only compared with New York Lorraine forms under the assumption of the upper Utica and Lorraine age of the beds. They have largely proven to be earlier species, especially so among the lamellibranchs. Unfortunately these earlier collections will not be accessible again for several years to come. Nevertheless the list gives a fair idea of the aspect and the size of the fauna of the Snake Hill beds. This large fauna has been greatly augmented and partly corrected by the later collections from Snake Hill itself, which are here listed as follows:

Dicranograptus nicholsoni *Hopkinson*	(c)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Corynoides *sp.*	(r)
Glyptocrinus *sp.*	(r)
Heterocrinus ? gracilis *Hall*	(c)
Cremacrinus *sp.*	(rr)

Carabocrinus *cf.* radiatus *Billings*	(rr)
Edrioaster saratogensis *nov.*	(r)
Paleschara ulrichi *nov.*	(r)
Schizocrania filosa (*Hall*)	(r)
Plectambonites sericeus typus (*Sowerby*)	(cc)
Plectorthis *sp. cf.* whitfieldi (*N. H. Winchell*)	(rr)
Dalmanella testudinaria (*Dalman*)	(cc)
Plaesiomys retrorsa (*Salter*)	(c)
Rafinesquina alternata (*Emmons*)	(c)
Clitambonites americanus (*Whitfield*)	(r)
Parastrophia hemiplicata *Hall*	(r)
Zygospira recurvirostris (*Hall*)	(r)
Whiteavesia cincta *nov.*	(r)
W. cumingsi *nov.*	(c)
Orthodesma ? subcarinatum *nov.*	(c)
Whitella elongata *nov.*	(r)
Clidophorus ventricosus *nov.*	(c)
C. foerstei *nov.*	(c)
Ctenodonta levata (*Hall*)	(c)
C. declivis *nov.*	(r)
C. prosseri *nov.*	(c)
C. radiata *nov.*	(r)
C. recta *nov.*	(r)
C. subcuneata *nov.*	(r)
Lyrodesma schucherti *nov.*	(rr)
Solenomya ? insperata *nov.*	(r)
Cuneamya acutifrons *Ulrich*	(r)
Archinacella orbiculata (*Hall*)	(c)
Cyclonema montrealense *Billings*	(r)
Cyclonema cushingi *nov.*	(r)
Clathrospira subconica *Hall*	(r)
Pterotheca *cf.* canaliculata (*Hall*)	(rr)
Eoharpes ottawensis (*Billings*)	(rr)
Trinucleus concentricus (*Eaton*)	(cc)
Proëtus undulostriatus (*Hall*)	(rr)
Calymmene senaria *Conrad*	(r)
Lepidocoleus jamesi *H. & W.*	(c)
Ctenobolbina subrotunda *Ruedemann*	(r)
Technophorus cancellatus *Ruedemann*	(r)

While the foregoing list cites only the fossils obtained on the cliff and slope of Snake hill, the cliff on the east shore of the lake, north of Snake hill, and the outcrops about Edgewater park on the west side have also furnished faunules that add to the Snake Hill congeries of species, especially to the graptolite biota:

Corynoides calicularis *Nicholson*	(cc)
Dicranograptus nicholsoni *Hopkinson*	(cc)

Glossograptus quadrimucronatus *mut.* pertenuis *Rued.*	
Diplograptus amplexicaulis *Hall*	(c)
D. amplexicaulis *var.* pertenuis *Rued.*	(c)
D. (Mesogr.) putillus (*Hall*)	(c)
Climacograptus scharenbergi *Lapworth*	(r)
C. spiniferus *Rued.*	(cc)
Plectambonites *sp.*	
Archinacella orbiculata (*Hall*)	(c)
Lepidocoleus jamesi *H. & W.*	(c)

The combined fauna of the Snake Hill beds, as known at present, is:

1 Dicranograptus nicholsoni *Hopkinson*
2 Diplograptus amplexicaulis *Hall*
3 D. amplexicaulis *var.* pertenuis *Rued.*
4 D. (Mesogr.) putillus *Hall*
5 Climacograptus scharenbergi *Lapworth*
6 C. spiniferus *Rued.*
7 Cryptograptus tricornis *Carr. mut.* insectiformis *Rued.*
8 Lasiograptus eucharis (*Hall*)
9 Glossograptus quadrimucronatus *Hall mut.* pertenuis *Rued.*
10 Corynoides calicularis *Nicholson*
11 Dawsonia campanulata *Nicholson*
12 Glyptocrinus *sp.*
13 Heterocrinus ? gracilis *Hall*
14 Cremacrinus *sp.*
15 Schizocrinus nodosus *Hall*
16 Carabocrinus *cf.* radiatus *Billings*
17 Edrioaster saratogensis *nov.*
18 Pontobdellopsis cometa *Rued.*
19 Paleschara ulrichi *nov.*
20 Pachydictya acuta (*Hall*)
21 Lingula curta *Conrad*
22 Leptobolus insignis *Hall*
23 Pholidops trentonensis *Hall*
24 Schizocrania filosa *Hall*
25 Plectambonites sericeus typus (*Sowerby*)
26 Plectorthis *sp. cf.* whitfieldi (*N. H. Winchell*)
27 Dalmanella testudinaria (*Dalman*)
28 Plaesiomys retrorsa (*Salter*)
29 Plectorthis plicatella *Hall*
30 Platystrophia biforata (*Schlotheim*)
31 Rafinesquina alternata (*Emmons*)
32 Clitambonites americanus (*Whitfield*)
33 Rhynchotrema inequivalve (*Castelnau*)
34 Parastrophia hemiplicata *Hall*
35 Cyclospira bisulcata (*Emmons*)
36 Zygospira recurvirostris (*Hall*)

37 Whiteavesia cincta *nov.*
38 W. cumingsi *nov.*
39 Orthodesma ? subcarinatum *nov.*
40 Whitella elongata *nov.*
41 Clidophorus ventricosus *nov.*
42 C. foerstei *nov.*
43 Ctenodonta levata (*Hall*)
44 C. declivis *nov.*
45 C. prosseri *nov.*
46 C. radiata *nov.*
47 C. recta *nov.*
48 C. subcuneata *nov.*
49 Lyrodesma schucherti *nov.*
50 Solenomya ? insperata *nov.*
51 Cuneamya acutifrons *Ulrich*
52 Archinacella orbiculata (*Hall*)
53 Cyclonema montrealense *Billings*
54 C. cushingi *nov.*
55 Clathrospira subconica *Hall*
56 Protowarthia *cf.* cancellata (*Hall*)
57 Pleurotomaria *cf.* lenticularis (*Hall*)
58 Murchisonia (Lophospira) uniangulata *var.* abbreviata *Hall*
59 Orthoceras tenuitextum (*Hall*)
60 O. lineolatum (*Hall*)
61 Spyroceras bilineatum (*Hall*)
62 Conularia trentonensis *Hall var.* multicosta *nov.*
63 Pterotheca *cf.* canaliculata (*Hall*)
64 Eoharpes ottawensis (*Billings*)
65 Trinucleus concentricus (*Eaton*)
66 Proëtus undulostriatus (*Hall*)
67 Triarthrus becki *Green*
68 Isotelus gigas *Dekay*
69 Acidaspis trentonensis *Hall*
70 Calymmene senaria *Conrad*
71 Pterygometopus callicephalus (*Hall*)
72 Ctenobolbina ciliata (*Emmons*)
73 C. ciliata *var.* cornuta *Ruedemann*
74 C. subrotunda *Ruedemann*
75 Lepidocoleus jamesi (*Hall & Whitfield*)
76 Turrilepas ? filosus *Ruedemann*
77 Pollicipes siluricus *Ruedemann*
78 Technophorus cancellatus *Ruedemann*[1]

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[1] To this list have to be added a number of interesting species which were obtained by the writer when this paper was already in press, at the excavations for the shops of the Delaware & Hudson R. R. at

In comparing these faunas with that of the Canajoharie shale, we find that most graptolites of the two formations are but little different. Closer scrutiny shows, however, that the Snake Hill beds contain certain forms which do not appear in the Canajoharie beds. The most important of these are: Climacograptus caudatus, C. scharenbergi, Cryptograptus tricornis mut. insectiformis. On the other hand, Climacograptus mohawkensis and Diplograptus quadrimucronatus mut. cornutus are peculiar to the Canajoharie shale. But also the forms which are common to both, show a marked difference in their frequency. Thus of Dicranograptus nicholsoni[1] and Climacograptus spiniferus[2] which are among the most common graptolites of the Snake Hill beds about Saratoga lake, the former is extremely rare in the Canajoharie beds, and the latter only frequent in the lower portion of the Canajoharie beds, about Hudson Falls and Ballston. On the other hand, Lasiograptus eucharis is all but absent in the Snake Hill beds, but well established in the parallel belt of Canajoharie beds, and while Corynoides calicularis occurs in both, C. gracilis, which occurs in the Snake Hill beds in several localities, seems to enter only the lower portion of the Canajoharie beds about Hudson Falls.

Watervliet, N. Y. The species new for this formation collected there are:

Trematis terminalis *Emmons*. Large form approaching T. millepunctata *Hall*

Schizambon fissus *var.* canadensis *Ami*. Large, long-spined specimens

Lingula obtusa *Hall*

Cyrtolites trentonensis *Conrad*. Much flattened specimens

Carinaropsis cf. carinata *Hall*. Large specimens

[1] As we have already noted, this species ranges here even into the Indian Ladder shale. This corresponds to the great range of the species in Europe, where it is cited from the zone of Nemagr. gracilis (corresponding to our Normanskill shale) in Sweden and reaches into the Hartfell shale in Great Britain.

[2] Climacogr. spiniferus was at first distinguished by us as C. typicalis mut. spinifer (title 60, p. 411) to identify a form figured by Hall (title 3, pl. 73, fig. 2a) as coming from Ballston, Saratoga county and which we have found to mark the shales directly overlying the basal Trenton limestone (Glens Falls limestone) at Hudson Falls (Sandy Hill). On account of its stratigraphic importance and apparent constancy of characters for a considerable length of time we prefer to distinguish this type as of specific rank (Cl. spiniferus).

Much more distinct is the difference between the Snake Hill beds and Canajoharie beds in the nongraptolitic portion of the fauna; for the former formation contains a great number of species that have not been observed in the Canajoharie beds, the most important of which are Edrioaster saratogensis, Carabocrinus, Orthis (Plaesiomys) retrorsa, Parastrophia hemiplicata, Zygospira recurvirostris, the many species of lamellibranchs, the trilobites Eoharpes ottawensis, Proëtus undulostriatus, also Pollicipes siluricus, Technophorus cancellatus, and the ostracods. On the other hand, the Canajoharie beds also contain a number of species not found in the Snake Hill beds, as Hyolithes pinniformis, Pterinea (Prolobella?) trentonensis and Pterinea insueta and a number of ostracods (Ulrichia? bivertex, Primitia unicornis).

When we now turn to the question of the relative position of the Snake Hill beds to the Canajoharie beds, we find several lines of evidence.

1 The common occurrence of a great number of fossils in both, which are absent above and below these two formations, as Diplograptus amplexicaulis and Corynoides calicularis, would indicate that both are either subdivisions of one formation or were deposited nearly contemporaneously in adjoining areas. If they are subdivisions of one formation, the faunal evidence would indicate that the Snake Hill beds are the older formation, for they contain in Cryptograptus tricornis, Climacograptus caudatus, C. scharenbergi, Plaesiomys retrorsa, Parastrophia hemiplicata, Edrioaster, Eoharpes ottawensis, etc., elements that indicate early Trenton or Black River age.

2 Geographically the belt of Snake Hill shales lies between the Canajoharie shales on the west and the Normanskill shales on the east. Although the complex folding and faulting of this region is little favorable to the drawing of inferences from the relative positions of the belt, the general observations noted in Bulletin 42, that the older rocks are found in the east and the beds as a rule become successively younger toward the west in the overturned and overthrusted closed folds have thus far proved correct. On the east side of Saratoga lake the Snake Hill and Normanskill shales become

even interfolded so that they form narrow alternating strips. We therefore infer that the Snake Hill beds lie closer to the Normanskill shales than the Canajoharie shales and are older than the latter.

3 At Hudson Falls and near Saratoga the Canajoharie shales rest directly on the Glens Falls limestone. The latter is according to Ulrich's determination, of very early (basal) Trenton age.

Since now the Canajoharie beds rest directly on the Glens Falls limestone and the Snake Hill beds are older than the Canajoharie beds, they must be absent in the western part of the Saratoga basin as well as in the Mohawk valley. Because of the fact that the Snake Hill beds are interfolded with the Canajoharie beds at the lower Mohawk and the western edge of the Hudson valley, we have considered them at first as deposited about the eastern edge of the Mohawk basin and as intercalated there between the Glens Falls limestone and the Canajoharie shale. Subsequent work, however, especially the summer's work of 1911 on the Schuylerville sheet, has shown that these shales reappear in a distinct belt on the east side of the Normanskill belt. They are therefore deposits of the same basin as the Normanskill shale. This inference is in accord with the observation that nowhere Snake Hill beds have been observed between the Glens Falls limestone and the Canajoharie beds, and it also accords with the faunal evidence that the Snake Hill sea had connections toward the north and east and thence received an important portion of its fauna. This latter evidence consists in the presence in the shales of Edrioaster, Carabocrinus, Eoharpes ottawensis and Orthis (Plaesiomys) retrorsa, all of which point to the St Lawrence and Ottawa Trenton rather than to the central New York Trenton. It is also noteworthy in this connection that Proëtus undulostriatus, of which we have obtained a well preserved carapace in the Snake Hill beds, is also known from the black pebbles (Black river?) of the Rysedorph Hill conglomerate and that the latter in its faunal connections also points east. Likewise Climacograptus caudatus is in America known only from the Snake Hill beds and the Magog shales in Canada and is an Atlantic form. Cryptograptus tricornis and Climacograptus scharenbergi have been directly taken from the Normanskill sea.

SUMMARY

The conclusions obtained in the preceding paper are:

1 The lower part of the black shale belt of the lower Mohawk valley hitherto referred to the Utica shale is of Trenton age and therefore here distinguished as *Canajoharie shale* from its typical outcrop at Canajoharie. The Canajoharie shale corresponds roughly to the lower and possibly middle Trenton of Trenton Falls and probably belongs in large part between the two. It disappears westward and is eastward cut off by the Hoffmans Ferry fault, but reappears north of Schenectady from under the Schenectady beds and eastward in the folded shales of the Hudson valley, where it is recognized in the Rural Cemetery beds, formerly referred by the author to the Magog shale of Canada. This belt can in the Hudson valley be followed northward through Saratoga county to Hudson Falls, where it rests on Glens Falls (basal Trenton) limestone.

2 The typical *Utica shale* seems to disappear entirely as it approaches the Hudson valley, probably through nondeposition.

3 The Frankfort shale is absent in the lower Mohawk valley. The shales, hitherto referred there to the Frankfort formation, are of older age. The Frankfort formation, in its restricted conception, soon disappears to the east of the type section near Utica, probably by overlap, and does not seem to have at all extended into the Hudson and Champlain valleys. According to its meager faunule it corresponds to the middle division of the Eden shale at Cincinnati and it may also include the upper Eden.

4 The so-called Frankfort beds of the lower Mohawk have furnished a large fauna that is very distinct from that of the Frankfort shale. Its most striking elements are the *eurypterids* and the seaweed Sphenophycus, but it also contains a number of species that indicate that it can not be younger than upper Trenton age and probably belongs mainly below the upper Trenton. Since these beds are connected by transitional beds with the underlying Canajoharie shale of lower and middle Trenton age, the inference of their middle and upper Trenton age is also supported by the stratigraphic relations. The formation is therefore here given a new name, the *Schenectady* formation. This formation attains a great thickness (approximately 2000 feet) in the lower Mohawk region, but does not extend far westward and ends abruptly eastward against the folded region. It is characterized by numerous intercalations of "bluestone," a calcareous sandstone, by mud-cracks, rapid horizontal alteration of sediments and other features which indicate nearness of the coast. This coast was probably to the east and the great

thickness of the Schenectady beds in this region is due to their formation in a sinking trough parallel to and in front of the Green Mountain-Taconic fold system. The Schenectady beds strike for this reason from north-northeast to south-southwest.

5 The uppermost portion, about 300 feet, of the "Frankfort" beds at their eastern edge in Albany county has been found to contain an entirely different fauna and also to be lithologically somewhat different. This division has been termed here the *Indian Ladder beds.* These rapidly disappear westward, being absent at Cobleskill and probably formed originally a narrow belt extending north-northeast to south-southwest; they are hence for the greater part buried under Devonic rocks in the south, and lost by erosion north of the Helderbergs, and only exposed to view in the Helderberg escarpment. The Indian Ladder beds contain the fauna of the Southgate division of the Eden shale and are hence of the age of part of the Frankfort beds but entirely different from them in their faunal aspect.

6 The *Brayman shales* which were originally referred to the Clinton and later were correlated with the Salina, appear to be the residual pyritiferous clays of the long hiatus corresponding to the time interval from the upper Trenton Schenectady shale to the Cobleskill limestone. They seem, however, sufficiently closely connected with the underlying sandstone at the top of the Schenectady shale to be considered as mainly formed in Upper Ordovicic time.

7 In the Hudson valley a belt of slates, grit and sandstones extends between the Canajoharie shale and Normanskill shale. It is distinguished from both by its fauna, and from the Canajoharie beds in the character of the shale and the greater intercalation of arenaceous beds. This shale which in the Hudson valley is well exposed on Green island, opposite Troy, and at Mechanicville, has received the name *Snake Hill beds* from its very fossiliferous outcrops at Snake hill, on the east side of Saratoga lake. It exhibits in its fauna evidence of being older than the Canajoharie shale and younger than the Normanskill shale and also distinct relations to the basal Trenton of the Ottawa basin, and properly belongs to the Levis basin where it follows the Normanskill shale.

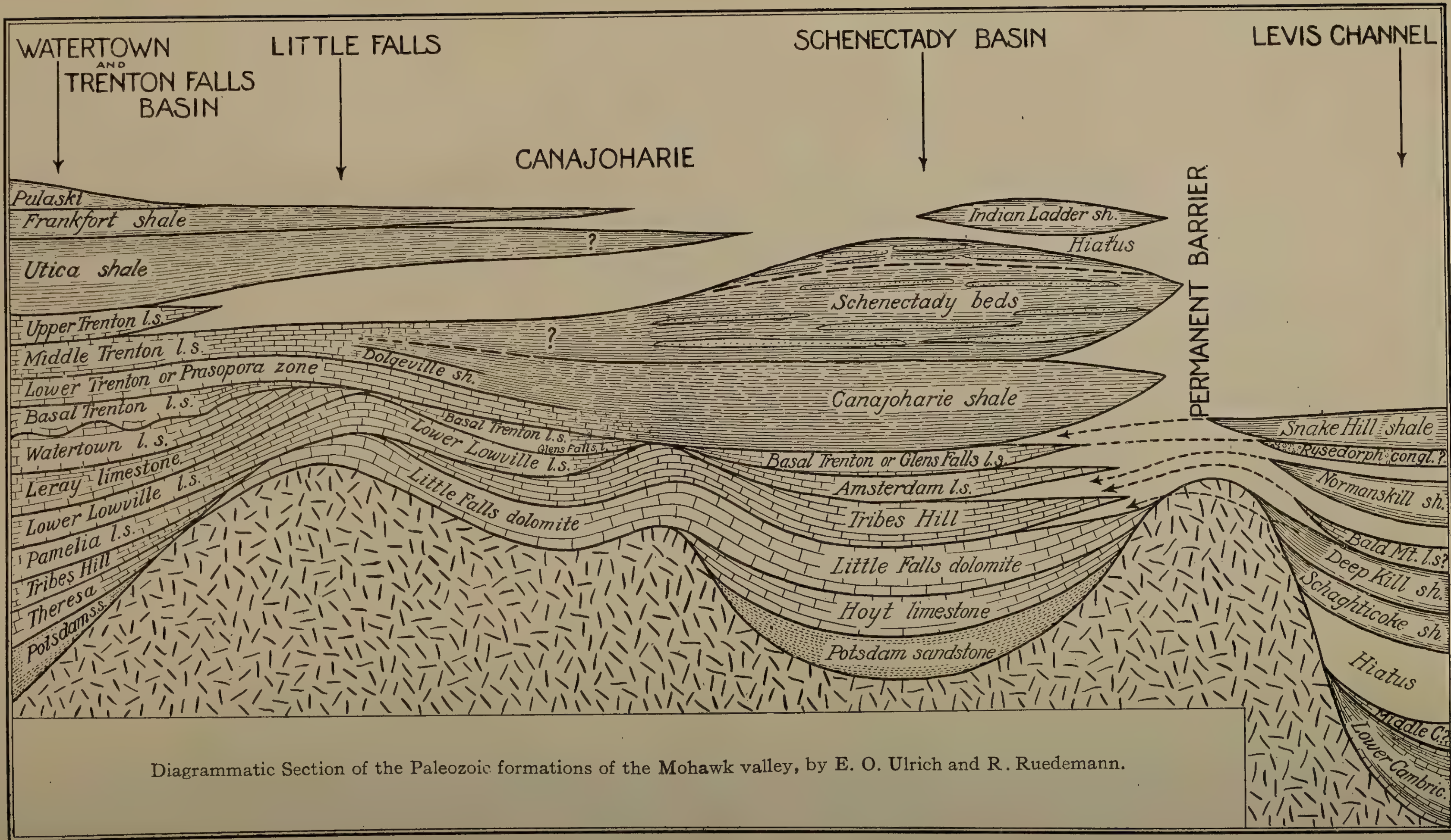
8 The Canajoharie, Utica and Frankfort shales seem to correspond to the three divisions of the Martinsburg shale of Pennsylvania, Maryland and Virginia, or to be a northern continuation of that formation; and the Frankfort shale can also be correlated with the middle part of the Eden shale of the Cincinnatian in Ohio.

Correlation table of the Cincinnatian and Upper Mohawkian groups of the Mohawk valley

<table>
<tr><th>OHIO VALLEY</th><th>UPPER MOHAWK VALLEY</th><th>LOWER MOHAWK VALLEY</th><th>PENNSYLVANIA–NEW JERSEY</th></tr>
<tr><td rowspan="2">Eden</td><td>Frankfort shale</td><td>Indian Ladder shale</td><td rowspan="6">Martinsburg shale</td></tr>
<tr><td>Utica shale</td><td></td></tr>
<tr><td rowspan="4">Trenton</td><td>Upper Trenton ls.</td><td rowspan="2">Schenectady beds</td></tr>
<tr><td>Middle Trenton ls.</td></tr>
<tr><td>Lower Trenton ls.</td><td>Canajoharie shale</td></tr>
<tr><td>Basal Trenton ls.</td><td>Glens Falls ls.</td></tr>
<tr><td rowspan="2">Black River</td><td></td><td>Amsterdam ls.</td><td rowspan="2">Jacksonburg ls.</td></tr>
<tr><td>Lowville ls.</td><td>Lowville ls.</td></tr>
</table>

Table of the Cincinnatian and Upper Mohawkian in the Mohawk valley

<table>
<tr><th>SECTION</th><th>TRENTON FALLS–UTICA</th><th>DOLGEVILLE–LITTLE FALLS</th><th>CANAJOHARIE–SHARON SPRINGS</th><th>AMSTERDAM–COBLESKILL</th><th>SCHENECTADY–INDIAN LADDER</th></tr>
<tr><td rowspan="2">Cincinnatian</td><td>Frankfort shale</td><td>Frankfort shale</td><td>Frankfort shale?</td><td></td><td>Indian Ladder beds</td></tr>
<tr><td>Utica shale</td><td>Utica shale</td><td>?</td><td></td><td></td></tr>
<tr><td rowspan="4">Upper Mohawkian</td><td>Upper Trenton limestone</td><td></td><td rowspan="2">?</td><td rowspan="2" colspan="2">Schenectady beds</td></tr>
<tr><td>Middle Trenton limestone</td><td>“ Utica shale ”
Dolgeville beds</td></tr>
<tr><td>Lower Trenton limestone</td><td>Lower Trenton limestone</td><td colspan="3">Canajoharie shale</td></tr>
<tr><td>Basal Trenton ls.</td><td>Basal Trenton ls.</td><td>Glens Falls ls.</td><td>Glens Falls ls.</td><td>Glens Falls ls.</td></tr>
</table>



Diagrammatic Section of the Paleozoic formations of the **Mohawk** valley, by E. O. Ulrich and R. Ruedemann.

Note to diagram

Doctor Ulrich and the writer have represented the stratigraphic results here obtained in the adjoined diagrammatic section of the Eopaleozoic formations of the Mohawk valley. The relations of the formations below the Trenton are reproduced as established through former investigations by E. O. Ulrich, H. P. Cushing and the writer. The relations of the Canajoharie and Schenectady beds to the Trenton limestone of the Trenton Falls basin are represented as described here. The upper Trenton limestone is drawn as abruptly terminating at the eastern edge of the Trenton Falls basin, because Doctor Ulrich failed to find it between Rathbone brook and Middleville, and the Utica shale is shown to diminish rapidly eastward, especially in its lower portion. The amount of its eastward extension in the Mohawk valley at present is not fully known. The Schenectady beds may at their top reach into the upper Trenton age and this transgression into the upper Trenton is indicated by the dotted line. The Indian Ladder beds appear as a lenticular body, since their main extension is in northeastern direction, crossing the east-west sectional plane in a very limited area.

Doctor Ulrich holds from his investigations that the Levis is the second trough east of the Schenectady basin and that the Chazy bay intervenes but is now covered by the overthrust Levis deposits. We have not attempted to introduce this condition on the diagram to the right of the permanent barrier because the exaggeration of the vertical scale would not permit its intelligible representation. The overthrust condition, however, which has brought the formation of the Levis basin in contact with those of the Schenectady basin in Albany and Saratoga counties, is indicated by the arrows showing the direction of the movement. We have further tentatively placed in the series of the Levis channel formations (mainly graptolite shales) a limestone outcropping about Bald mountain. From fossils collected last summer by the writer it is determined as of upper Beekmantown age. The Rysedorph Hill conglomerate, which also outcrops at various localities, belongs with the Levis channel graptolite beds and probably lies between the Normanskill shale and Snake Hill beds.

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PALEONTOLOGICAL NOTES

Sphenophycus nom. prop.

The work in the Schenectady shales has brought to light a great quantity of finely preserved algal remains. In part these are identical with Sphenothallus latifolius, described by Hall from the top beds of the formation at Schoharie, but the greater part represents one or more different species, and many exhibit important features not shown by the original material. We should not have undertaken to describe these if we had not had the authoritative advice and encouragement of Mr David White regarding them, but we should have much preferred if Mr White would himself have agreed to write a note on these Lower Siluric algae.

Hall (title 3, p. 261) described the genus Sphenothallus as follows: " Plant consisting of a stem, with diverging wedge-form leaves, or of detached leaves having this form. Leaves apparently succulent or thickened, and sometimes subcoriaceous." He cites two species as belonging to it, viz, Sphenothallus angustifolius and S. latifolius. The former has been found by us as a rather frequent fossil in the Utica shale of Dolgeville and elsewhere and on reinvestigation (1897, N. Y. State Geol. Rep't 15) was referred to as a " sessile Conularia." The stem of the type specimen was found to be a cephalopod shell, to which the " leaves " are attached by basal disks. While we no longer consider this species as properly belonging to the genus Conularia itself, there is no doubt in our minds of its taxonomic position with the Conularidae. It therefore can not be retained in the same genus with the other species, S. latifolius, if the latter is an alga, and the question arises which of the two should retain the generic name Sphenothallus. S. angustifolius is the first species described under the diagnosis and moreover the latter is

clearly shaped principally after this species. If, therefore, S. angustifolius is a conularid, but not congeneric with Conularia, it should retain the generic name and a new one be selected for the second species. We therefore propose here the name *Sphenophycus* for the second species.

Both Sphenothallus angustifolius and Sphenophycus latifolius possess remarkably thick carbonaceous tests. That of Sphenothallus angustifolius also contains phosphate of lime and has the appearance of having originated from a chitinous or conchiolinous substance. Following a suggestion of Mr White, I tested the organic matter of Sphenophycus by fire and found that it burns with a fair degree of completeness, leaving an ash residue consisting of clay and silica and probably resulting from silt infiltration into the canals of the organism. This evidence suggests the vegetable nature of the carbonaceous tests.

The most remarkable portions of these vegetable remains are the club-shaped bodies reproduced on plate 2, figures 1–13. These were all obtained in one block that had fallen from the cliff overhanging the Mohawk river at Aqueduct. They consist of an elliptical or circular distal smooth body borne on an equally smooth pedicel. The distal body is in well-preserved specimens flattened at the apex and in some this part is infolded. The wrinkles and partial sections prove that the distal bodies were originally more or less inflated and the pedicel tubular (see section, plate 2, figure 8). The outline of these problematic fossils, a large number of which were obtained from the block, proved suggestive of a variety of animal objects, notably of chimaeroid, gastropod and cephalopod egg-cases, all of which suggestions were disproved by the kind advice of Messrs Bashford Dean, Gratacap and Pilsbry. Mr White has expressed the opinion to us that these bodies are algal flotation appendages. A specimen was observed showing these bladders attached to a spirally arranged group of the thalli of a Sphenophycus. It broke when lifted up; the portion saved is reproduced on plate 2, figure 13. This specimen and the apparent absence of any apertures of the bulbs or of any substance originally inclosed within them, are strong arguments in favor of that view. Likewise, the absence of any coarser surface sculpture on the bulbs, the extreme length of the pedicels in some and its unvaryingly torn proximal extremity, as well as the fibrous character of the pedicel seen in some examples, and the auxiliary bulblike inflations (see plate 2, figure 11) in the pedicel, point to the vegetable origin of these

fossils and their character of flotation appendages. We are not sure yet to which of the two species here distinguished they belong, although the present evidence indicates that they are referable to S. latifolius.

Several specimens of S. latifolius appear at first glance lobate (see plate 1, figure 1). It has been pointed out to me by Mr White that this appearance is due to the presence of cuplike marginal cavities and that these are apparently connected with the neural system which is canalicular. These cups and the canals are well seen in plate 1, figure 2.

Besides the genotype, S. latifolius, which according to the original description possesses "broadly cuneate thalli,[1]" we have distinguished a second species, but there are probably more than two species present, as indicated by such thalli as those reproduced in plate 1, figure 9. The cuneate thalli of S. latifolius were probably arranged spirally around a stem, as indicated by their wedgelike shape and by the specimen plate 1, figure 13.

The largest thalli found are those typically represented by plate 1, figure 5. While also possessing a broadly cuneate to trapezoidal outline, they are not single as those of S. latifolius, but, as again pointed out to us by Mr White, "composed of rather slender, but rigid conical thalli, originating at the scarlike pits or depressions of the lower parts of the axis."

A third type is represented by plate 1, figure 9. Only one specimen of this interesting form has been thus far obtained. It shows a pitted middle axis from which proceed lobate thalli, ornamented with broadly recurving lines. This material we consider too imperfect for specific differentiation.

Cyathodictya ? tubularis nov.

Certain layers of the Canajoharie beds at Canajoharie are covered with multitudes of small elongate bodies which contrast by their brown coloring with the black shale. These bodies are mostly about 5 mm long and then regularly conical in outline, but reach as

[1] The original description is: "Leaves broadly cuneate, somewhat thickened at the outer margin, and truncate at the lower extremity; surface obscurely striated. The specimens are often marked on one side by a ridge or midrib along the center, and sometimes transversely wrinkled. These leaves all appear to have been thick and succulent, like the Fuci."

much as 15 mm in length and these larger specimens are cylindrical in outline. While completely flattened out, the roundish aperture at one end and the thickened lateral margins demonstrate that the bodies were originally tubular and rather thick-walled. The proximal end fades out in most specimens; in many others it is jagged as if broken off and in a few it contracts to a blunt point. The long tubular specimens show no appreciable contraction at either end.

Fig. 8

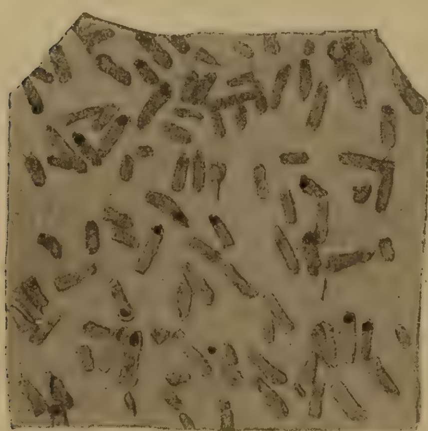

Fig. 9

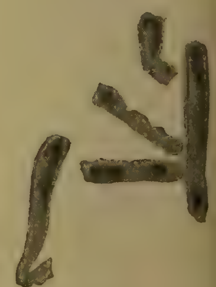

Fig. 12

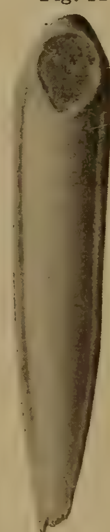

Fig. 11

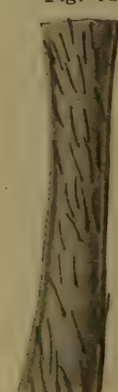

Fig. 10

Fig. 8–12. Cyathodictya ? tubularis nov.

Fig. 8. Group of specimens of usual size. Natural size. Fig. 9. Group of large specimens. Natural size. Fig. 10. Specimen showing aperture, x 5. Fig. 11. Specimen showing spicules, x 5. Fig. 12. Fairly perfect specimen. Type, x 5.

Canajoharie shale at Canajoharie, N. Y.

The substance of the fossil is preserved and this as well as the thick margins show the walls to have been quite substantial.

We have referred this gregarious organism with doubt to Cyathodictya largely on account of the form and thick walls of the bodies. Owing to their small size we have not been able to satisfy ourselves as to the presence of spicules although delicate lines suggesting these are seen in some places on the walls, the longitudinal

spicules being more distinct in some, the transverse in others. Larger dictyonine spicules (typical hexactines), corresponding in size to those of the Utica species C. reticulata (Walcott) have been found in adjoining layers, demonstrating the actual presence of dictyosponges in these beds.

Fig. 14

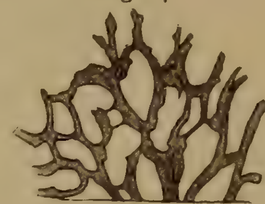

Fig. 13

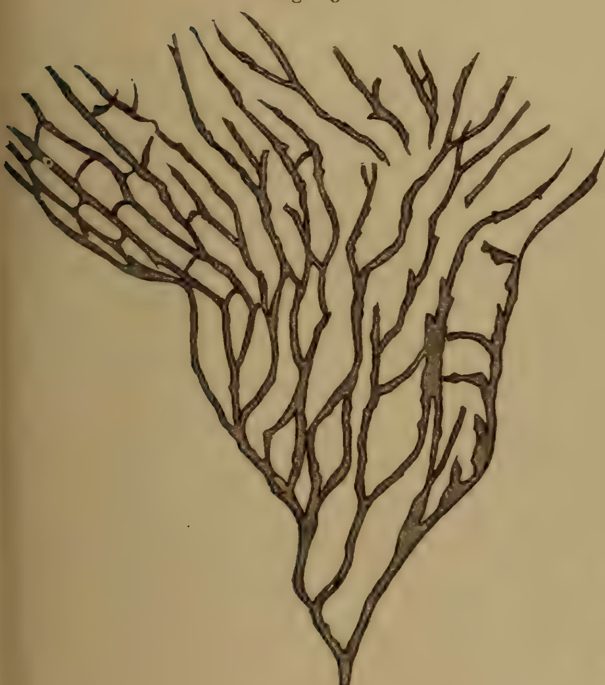

Fig. 15

Fig. 13–15. Dictyonema arbuscula (Ulrich)

Fig. 13. Small rhabdosome, x 5. Fig. 14, 15. Fragments of distal portions of larger rhabdosomes, x 5.
Indian Ladder beds, at the Indian Ladder, N. Y.

Dictyonema arbuscula (Ulrich)

Pl. 2, fig. 15

A small Dictyonema was found to be not infrequent in the Indian Ladder shale at the Indian Ladder, which proved to be identical with a species hitherto recorded only from the Eden (formerly Utica) shale of the neighborhood of Cincinnati. According to Doctor Ulrich this species occurs in the Middle Third of the Eden shale. It was first described and figured in 1879 (title 8, p. 28) and also

noted in the Graptolites of New York, part 2 (title 60, p. 151). Like other Dictyonemas this species also shows a tendency to undulating, alternatingly adnascing branches in the proximal portion, giving that part a Desmograptuslike aspect, while it is a typical Dictyonema in the distal portions (see text fig. 13).

Dictyonema multiramosum nov.

Pl. 2, fig. 16

Description. Rhabdosome of small size (32 mm high) apparently cyathiform, arising from a short thick stem. Branches extremely thin and closely arranged, about .5 mm apart and .2 mm wide, bifurcating at frequent intervals, slightly undulating; mostly of rather straight appearance, frequently coalescing where brought in contact by the wavy form of the branches, or where the latter are straight, with thin dissepiments in long intervals. Thecae not clearly seen.

Fig. 16. Dictyonema multiramosum nov.

Portion of rhabdosome, x 5. Schenectady beds, Rotterdam Junction, N. Y.

Horizon and locality. Schenectady beds near Rotterdam Junction, N. Y.

Remarks. But a single specimen of this species was obtained and this being inclosed in a sandy shale, is far from perfect in preservation. It is therefore possible that the species should be rather referred to Desmograptus which it approaches in some portions of the frond.

We have not observed any species in either the Trenton or Utica shales which approaches D. multiramosum in the extreme delicateness of the rhabdosome.

Dicranograptus nicholsoni Hopkinson var. **parvulus** nov.

The Canajoharie shale at Morphy's creek near Pattersonville, N. Y., contains in its basal layers, within a few feet of the underlying Glens Falls limestone a diminutive form of Dicranograptus nicholsoni which deserves recognition as a variety, as all the specimens of this bed retain uniformly their peculiar character.

The main differences from the typical nicholsoni are the closer arrangement or smaller size of the thecae, which number 14 in 10 mm, and the greatly varying length of the biserial portion (4–11 mm). The form of the thecae does not seem to differ from that of the larger types. The biserial portion has been seen in only one specimen and in this the axillary angle is smaller than in nicholsoni typus, namely about 10°.

The width of the stipe is not materially different from that of nicholsoni.

The most remarkable feature of the specimen retaining the biserial portion is the continuation of the axes of the biserial branches in antisicular direction. These axes have to our knowledge not been observed in either Dicellograptus or Dicranograptus outside of the theciferous portion. The free portions are too long and delicate to have been theciferous and to have secondarily become separated from the thecae. The rhabdosome of Dicranograptus was hence suspended from two axes which, as the parallel and slightly convergent final direction of the axes suggests, proceeded from a common initial point.

The specimen exhibits also a large "web" between the branches.

Fig. 17

Fig. 18

Fig. 17, 18. Dicranograptus nicholsoni Hopkinson var. parvulus nov.

Fig. 17. Specimen showing axes or nemacauli, x 5. Fig. 18. Long biserial portion of specimen showing form of thecae, x 5. Canajoharie shale, Morphy creek, N. Y.

Dicellograptus nicholsoni possesses in the slate belt of New York a much larger *vertical range* than we had inferred in Memoir 11, page 318. We had cited it there from the "Trenton shales" (Normanskill shale) in several varieties and in typical development from the Utica of South Trenton, the Mohawk valley and the shales at Saratoga lake, which were also supposed to be of Utica age. The shales which carry D. nicholsoni in the Mohawk valley are in the present paper referred to the Trenton as Canajoharie shale and those at Saratoga lake are also correlated with the Trenton as Snake Hill beds. The Normans-

kill shale is now considered as being as old as the Chazy formation. We have also found a specimen in the Indian Ladder beds. This species ranges therefore in the shales of Eastern New York from the Chazy formation to the top of the Lower Siluric.

Diplograptus (Mesograptus) putillus Hall

Hall originally described as Graptolithus putillus in the Canadian Organic Remains, decade 2, a small graptolite from the "Hudson River group" of Iowa, that afterward was found to range through the Eden beds of Ohio (title 49, page 68) and to occur in many localities in the Utica shale of New York (title 60, page 416). Our subsequent work has shown that this minute type ranges in several mutations which are especially characterized by different size, from the Normanskill shale through the Snake Hill beds, the Canajoharie shale into the Utica shale. One of these (from the Normanskill shale) has been distinguished before as Climacograptus putillus mut. eximius (op. cit. page 420). Also the mutation of the true Utica horizon is distinguished by extremely small size, while those of the Canajoharie and especially the Snake Hill beds are remarkable for their greater size. It must be these larger mutations which characterize in Sweden a zone below that of Diplograptus quadrimucronatus.

The species has been currently referred to Diplograptus, while the present writer placed it in the Graptolites of New York with Climacograptus on account of the frequent Climacograptus aspect of the rhabdosomes. Part 6 of the "British graptolites" by Lapworth, Elles and Wood (title 58, page 256), proposes the subgenus Mesograptus for "forms in which the appearances presented are in part those characteristic of a typical Diplograptus (Orthograptus) and in part those more characteristic of a typical Climacograptus." It would seem that the subgenus Glyptograptus also contains forms quite similar to our species.

Diplograptus (Mesograptus) mohawkensis nov.

Pl. 2, figs. 18, 19

Diplograptus foliaceus (in part) *auctorum.*

Rhabdosome small, about 15–22 mm in length and 1.5–2 mm in width; the latter rapidly attained (in about 3 mm), in the largest specimen again narrowing in antisicular direction. The sicula has

not been observed; the virgella is stout and 1.5 mm long. Thecae 12–14 in 10 mm; having the Climacograptus aspect in both views in the proximal narrowed portion and throughout in the obverse aspect, and the Diplograptus aspect in the reverse aspect; having an average length of 1.5 mm and overlapping one-half of their length. The first thecae are narrow and with their outer walls but slightly inclined to the axis, the later thecae have oblique straight ventral margins in the reverse aspect and sigmoidal ventral margins in the obverse aspect. The excavation in the latter aspect is fairly deep (one-fourth the width of the rhabdosome); the apertural margin nearly straight.

Horizon and localities. In the lowest part of the Canajoharie shale at Morphy's and Swartztown creeks near Amsterdam, N. Y., and at the Carlsbad spring near Saratoga, N. Y.

Remarks. This species is one of the various forms that have been referred in our shales first to Diplograptus pristis Hall, and later to D. foliaceus Murchison; but it is readily distinguished from the rest by the striking difference in the two aspects, the obverse which is that of a Climacograptus, and the reverse which is that of a Diplograptus. In the Monograph of the British Graptolites the subgenus Mesograptus is proposed for that group of Diplograpti in which the stipe is conspicuously concavo-convex in section and the appearance of the thecae different in the two aspects. In the second of the two groups again distinguished under the Mesograpti, the excavations of the Climacograptus aspect are deep and conspicuous throughout. This condition, for which the subgenus Amplexograptus is proposed, is approached, if not reached, by the present form, although the excavations are not as deep as in the typical Amplexograpti.

Fig. 19 Fig. 20

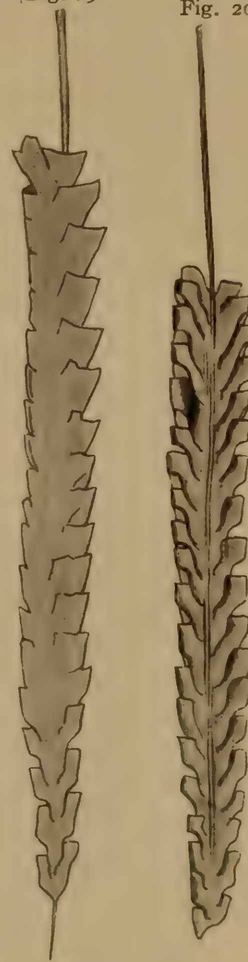

Fig. 19, 20. Diplograptus (Mesograptus) mohawkensis nov.

Fig. 19. Reverse aspect, x 5. Swartztown creek, N. Y.

Fig. 20. Obverse aspect, x 5. Carlsbad Spring near Saratoga, N. Y.

The species occurs almost to the exclusion of others and in profuse numbers in the basal beds at Swartztown creek and Morphy's creek and is quite obviously characteristic of the lowest zone of the

Canajoharie beds. It reaches there but 15 mm in length, and appears to have possessed a rather tenuous periderm. At the Carlsbad spring the specimens reach a greater size. From the geographic position of these latter shales near the Glens Falls belt of Rowland mills, we infer that these shales also lie near the base of the Canajoharie beds.

From the typical Diplograptus (Mesograptus) foliaceus this species is distinguished by its smaller size, narrower sicular portion and the stronger sigmoidal curvature of the ventral walls of the thecae in the obverse aspect. It does not seem, however, to be nearer related to any of the other British Lower Siluric Diplograpti.

Diplograptus (Amplexograptus) macer nov.

Pl. 2, figs. 20, 21

Description. Rhabdosome slender, 20–25 mm long with a maximal width of 1.5 mm, which is very gradually attained. Sicula not observed. Virgella small and inconspicuous. Thecae 12–14 in 10 mm, about 1.5 mm long, inclined 10°–12°, overlapping about one-half their length, with fairly straight or slightly sigmoidal ventral and straight to slightly concave apertural margins on the reverse aspect and straight vertical ventral margins and deep (one-third the width of rhabdosome) apertural excavations on the obverse aspect.

Horizon and locality. The top beds of the Canajoharie shale in the Minaville section are characterized by this species.

Remarks. D. macer is easily distinguished from the other Diplograpti of the "Utica" shale by its narrow, slender form, the closely arranged thecae and the very different appearance of the two sides; the rather deeply notched obverse aspect being especially easy of recognition. This aspect characterizes the species as falling within the subgenus Amplexograptus of Diplograptus. It would seem to be a further development of that of the earlier D. mohawkensis.

This species is in many features very similar to D. (Amplexograptus) arctus Elles & Wood, an earlier British form of the Dicranograptus shales, and is possibly a later mutation of the latter. The principal distinguishing features are the larger size and the long virgella of D. arctus.

Diplograptus vespertinus Ruedemann

In the Graptolites of New York, Memoir 11, page 352, the author has distinguished a form as mut. vespertinus of Diplograptus foliaceus Murchison, occurring typically in the

Fig. 21

Fig. 22

Fig. 23

Fig. 21, 22. Diplograptus (Amplexograptus) măcer nov.
Fig. 21. Reverse aspect. Fig. 22. Obverse aspect. Both x 5.
Canajoharie shale, Minaville, N. Y.

Fig. 23. Diplograptus peosta Hall.
Specimen from Indian Ladder beds at the Indian Ladder, N. Y. x 5.

"Utica shale" of the Mohawk valley and Hudson valley, and the Lorraine beds. More recent work in these shales has shown that

it will be necessary to distinguish these Diplograpti more sharply if they are to be of any use in the elaboration of the stratigraphy of the shales. We therefore for the present restrict vespertinus to the forms from the Canajoharie shale. Since Diplograptus foliaceus Murchison, as since emended by Elles & Wood, clearly represents a different type, we recognize D. vespertinus as a distinct species.

Climacograptus spiniferus Ruedemann

We comprise under this name the form which in the Graptolites of New York, part 2, page 411, had been described as C. typicalis mut. spinifer from the shales at Ballston, Saratoga and Bakers Falls (now Hudson Falls). This type is a common and characteristic graptolite of the Canajoharie shale where C. typicalis is absent; it also occurs in the Snake Hill shale and enters into the Schenectady beds. It is therefore in its range, as also in its characters, so very distinct from C. typicalis that it should be recognized as a different species. I learn from Doctor Ulrich that it also is a characteristic graptolite of a part of the Martinsburg shale. The Mohawkian mutations of C. bicornis (a Normanskill species) that have been cited by several authors, the present included, probably all belong to spiniferus.

Lasiograptus (Thysanograptus) eucharis (Hall)

This minute form, which is remarkable for the frequent occurrence of entire colonies or synrhabdosomes, was originally described by Hall as a Retiograptus, later, on account of the form of the thecae, referred by the present writer to Diplograptus and in the Graptolites of New York, part 2, page 397, brought with doubt under Glossograptus. Last summer's investigation of the shales of the Mohawk valley has afforded the writer a few specimens from the Canajoharie shale of the Chuctenunda section and the Schenectady shale of Schenectady, which at last establish the generic position of this species. While those from the Chuctenunda reveal the marginal lacework characteristic of Lasiograptus, the specimens from Schenectady are partly pyritized and retain the fibrous thickenings of the angles of the thecal walls (see text figure 24).

Fig. 26 Fig. 27 Fig. 28 Fig. 24 Fig. 25

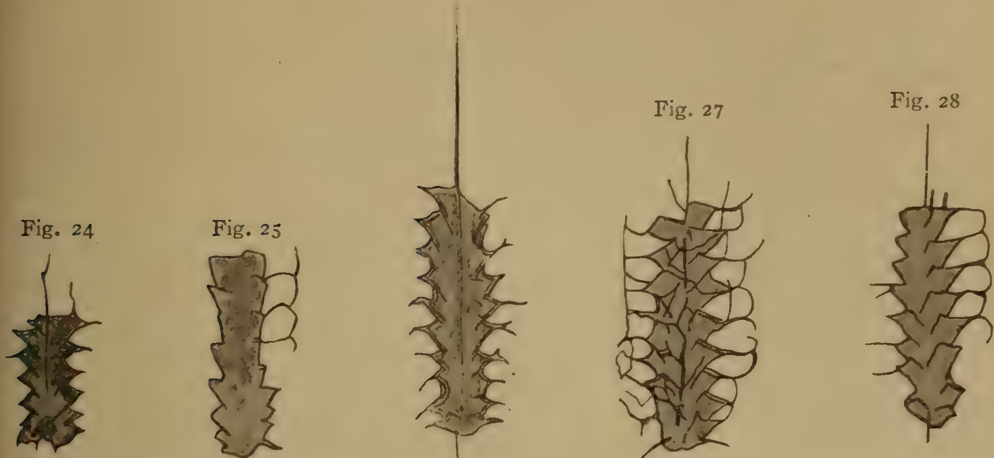

Fig. 24–28. Lasiograptus (Thysanograptus) eucharis (Hall).

Fig. 24. Pyrityzed specimen showing fibrous thickenings of the margins. Fig. 25. Specimen showing traces of the extra marginal lacework (lacinia). Fig. 26. Specimen showing pyritized marginal thickenings and ventral processes. Fig. 27. Specimen with fairly complete lacinia. Fig. 28. Specimen with a different aspect of the lacinia. All x 5.

Originals of Figs. 24 and 26 from Schenectady beds of Dettbarn quarry near Schenectady, N. Y.; those of Figs. 25, 27, 28 from Canajoharie shale Chuctenunda creek near Amsterdam, N. Y.

The genus Lasiograptus has been extended by Elles and Wood in their splendid Monograph of the British Graptolites (title 58, page 318), and several subgenera distinguished. Our species would correspond to their subgenus Thysanograptus in which the thecae are of the typical Amplexograptus form, and the ventral processes unite to form a complete ventral lacinia. In its general dimensions L. eucharis resembles the British L. harknessi Nicholson; it is, however, distinguished by the closer arrangement of the thecae.

In the Monograph of the Graptolites of New York, volume 2, L. eucharis is cited as occurring in the Utica shale and the "Trenton-Utica transition beds" of Panton, Vt. In our work, carried on since the publication of that volume, we have found that species also in the Snake Hill and Canajoharie shales which are of Trenton age and in the Frankfort shale, so that the range of L. eucharis is found to extend both below and above the Utica shale.

Glyptocrinus sp.

The presence of a species of Glyptocrinus in the Snake Hill sandstone is proven by a calyx and numerous stems with the characteristic alternation of larger and smaller joints. The calyx was about

the size of that of G. decadactylus and while distinctly showing the numerous interbrachials of Glyptocrinus, it is not well enough preserved for close determination.

Heterocrinus ? gracilis Hall

Pl. 3, fig. 5

Hall (title 3, page 280, plate 74, figure 3) describes and figures as Heterocrinus ? gracilis an extremely small, slender crinoid, of which he states that " it occurs in the soft olive shale at Snake hill, Saratoga county, N. Y." Since Hall was unable to make out the arrangement of the calyx-plates, the species can not be considered as properly defined. It is, however, obvious to the collector that the shale, and especially a thin, dark gray sandstone bed at Snake hill, contains this and other coarser crinoids in considerable number. Unfortunately we have been unable thus far to obtain satisfactory material. We figure here a specimen of H. ? gracilis which permits a view of a part of the calyx, but defer the generic determination of this minute crinoid until better material has been obtained.

Cremacrinus sp.

Doctor Ulrich has kindly directed my attention to the presence of a specimen of Cremacrinus in the shaly Snake Hill sandstone. The specimen probably represents a new species since the calyx and whole body are more slender than the other congeneric forms; but we do not feel warranted, with the incomplete material before us, to do more at present than note the presence of this genus in the Snake Hill beds.

Carabocrinus cf. radiatus Billings

Pl. 3, fig. 6

The citation of this species among the Snake Hill fossils is based upon a single calyx plate which well exhibits the characteristic angular radiating sculpture lines of that species and corresponds to the basals (subradials) in outline. C. radiatus is known from the Trenton limestone of Ottawa.

Edrioaster saratogensis nov.

Pl. 3, figs. 2–4

Body of small size, about 14 mm in diameter, discoid, gently convex on the oral side; aboral surface not seen; apparently not attached.

Thecal plates irregular polygonal, mosaic, disposed without order and of small number; their surface granulose. Usually three or four large plates in the interambulacra, the marginal plates not seen.

Rays five, four solar and one contrasolar, broad and nearly straight in the proximal half, the extremital part rather abruptly bent and terminating within the disk subparallel to the margin. Oral aperture elongate, two rays arising from one, and three from the other end, surrounded by (five?) triangular oral plates with raised lateral edges. Ambulacra covered by two rows of alternating, inwardly converging, contiguous narrow plates with flat, horizontally extended tops. Subambulacral plates polygonal, as the thecal plates, but smaller, apparently hexagonal (the outer margins not clearly seen). Cover plates granulose, as the thecal plates. Anal pyramid small, consisting of four triangular plates, situated as in Agelacrinites, between the distally approaching or overlapping pair of solar and contrasolar rays.

Horizon and locality. Snake Hill shale and sandstone at Snake hill, Saratoga county, N. Y.

Remarks. This small and interesting type occurs only in molds in graywacke sandstone, which has been found loose in slabs under the cliff on the shore of the lake but not in place. Altogether four specimens were obtained by me.

The species is clearly congeneric with E. bigsbyi Billings, from the Trenton of Ottawa. It agrees exactly with that species, and since the latter is the type of the genus, also with the genus, in the form of the ambulacra and their coverplates, the form of the tegal plates and their sculpture. The oral and ambulacral plates, as well as the anal pyramid of Edrioaster bigsbyi have not yet been described and it is therefore still possible that they differ in the genotype, and the reference of our species to Edrioaster is doubtful in that respect.

Billings described E. bigsbyi as possessing four rows of pores in the ambulacra. Jaekel (title 43, page 44) has pointed out that these pores, if they existed, had probably nothing to do with the pores of the Cystoidea, but only served for the entrance of water into the vectacle furrows or for the discharge of sexual products. In E. saratogensis the cover plates fit snugly against each other wherever well preserved and have straight lateral sides, leaving no room for pores. In a few places, however, where the plates are apparently somewhat abraded, they are contracted in the middle, leaving long elliptic depressions between them.

Jaekel refers a second species, E. buchianus Forbes sp. (from Bather's ms.) to Edrioaster, basing his generic description on both forms. He describes the body as spherical from the cast of E. buchianus. E. saratogensis appears as a low spherical segment, but there is evidence of a flattening of the body in the pushing of plates over each other, and since the underside is not preserved in our material, it is possible that E. saratogensis also was originally spherical.

The direction of the spiral course of the ambulacra was in E. saratogensis apparently already fixed in distinction to E. bigsbyi, where it could be solar or contrasolar; and it has already reached the condition of the ambulacral rays of Agelacrinites.

The anal pyramid of E. buchianus is, according to Bather, surrounded by irregular plates. Also in this character E. saratogensis would seem to have advanced somewhat in showing a regular pyramid.

We have seen nothing that could be recognized as a madreporite.

All three known species of Edrioaster are of approximately the same age.

Taeniaster schohariae nov.

Pl. 3, fig. 1

This interesting species of Paleozoic Ophiuroidae or brittle stars, is based on a single individual, retaining three arms, one of which presents the ventral view and the other two their lateral views, resp. sections. The specimen is small, the arms about 15 mm long, and it is without a disk. The arms are slender and flexible, about 1.3 mm wide at the base, and almost as high in lateral view, originally probably cylindrical. The ventral view shows a straight or slightly zig-zagged ambulacral canal, and on both sides of this squarish depressions surrounded by the ambulacral and adambulacral ossicles, the covering lower arm plates not being retained if they existed. The inner (ambulacral or vertebral) ossicles appear as narrow and outwardly curved ridges, the outer or adambulacral ossicles as ridges bent in the opposite direction with a projection in the middle of the outer arch. The ambulacral ossicles are not directly opposite nor regularly alternating, but those of the right side on the ventral view advanced about one-third the length of the ossicles beyond those of the other side.

The lateral view of one other arm exhibits the ossicles as vertical bars, that are thickened at both ends resembling vertebrae and terminating at the dorsal side with a flat surface and forming there an apparently continuous layer. They appear almost twice as wide as the intervening spaces. The dorsal surface bears bundles of obliquely forward directed spines, one bundle corresponding to each ossicle. These spines appear in the right arm to proceed from small spine-bearing plates attached to the adambulacrals, as in the closely related Bundenbachia. On one arm two bundles are seen to proceed from each segment, one oblique, the other vertical to the arm. The oral skeleton consists of stout, bifid pieces, much resembling the oral pairs of adambulacrals of the genotype.

Horizon and locality. Upper Schenectady beds near Schoharie Junction, Schoharie county, N. Y.

Remarks. The genus Taeniaster was founded by Billings (title 4, page 80) on the Trenton species T. spinosus and T. cylindricus. The latter of these species has been made the type of the new genus Taeniura by Gregory (title 31, page 1035); Parks[1] however has pointed out that from inspection of Billings's type specimen he would rather refer the species to Lapworthura, Gregory. However that may be, we will consider here the genus Taeniaster as represented only by T. spinosus and T. elegans Miller. In that case our specimen would show the same general form and arrangement of the ossicles as both these species, but differ from both by its more slender arms. The shape of the ossicles resembles especially those of Taeniaster elegans, as figured by Miller,[2] but we presume that Miller's figure is somewhat diagrammatic. Parks states that T. elegans would seem to be a true Protaster, but for the fact that no disk is present. The same would be probably true of our species, for Parks's figure 4, giving the ventral view of an arm, presents a picture well comparable to the view of our middle arm, in the shape and arrangement of the ossicles, with the difference that the latter in our specimen appear much thinner.

There is no evidence observable in our specimen of any other plates but the so-called vertebral ossicles with the possible exception of the spine-bearing ossicles; it is therefore probable that T. schohariae possessed only this interior skeleton and no covering plates, a feature which is claimed by Stürtz (title 16,

[1] Canadian Institute, Trans. 1907–8, 8: 371.

[2] Jour. Cinc. Soc. Nat. Hist. v. 5, 1882, pl. 1, fig. 6.

p. 234) for the whole suborder Ophio-encrinasteriae. Gregory, however, states that the true Taeniaster is asteroid in oral armature, in its alternately arranged ambulacral ossicles and in the absence of a disk.

Stürtz, *ibidem,* points out that Taeniaster and Bundenbachia exhibit a flexibility of the arms vertically to the disk which is among recent ophiurans found only in Ophiotholia. Our specimen is also preserved in a lateral view showing the same peculiar position of the arms.

Paleschara ulrichi nov.

Zoarium incrusting or parasitic mostly upon cephalopod shells, covering the entire surface, consisting of relatively large oblong polygonal (mostly irregularly pentagonal or hexagonal) cells (9 to 12 in space of 10 mm) with thin, low walls.

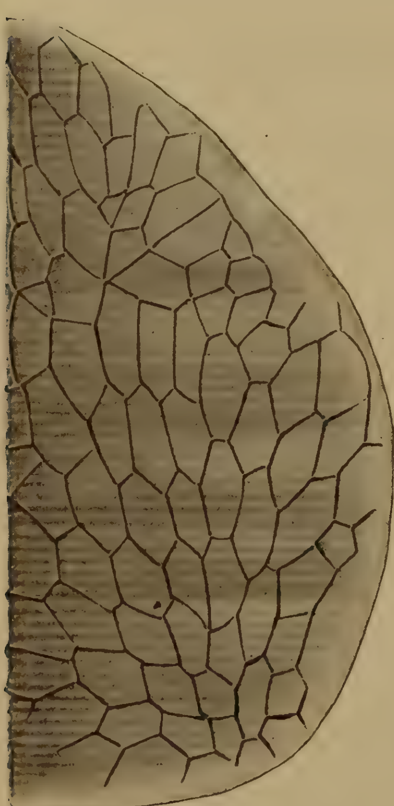

Fig. 29. Paleschara ulrichi nov.

Portion of zoarium, x 10. From Snake Hill beds at Snake hill, Saratoga county, N. Y.

Doctor Ulrich informs me that this species has larger and less regularly arranged cells than are found in its chronologically nearest relatives. Paleschara occurs in the Helderbergian, Niagaran, Richmondian and rarely in the Eden. With this species its range is extended downward to early Trenton.

Position and locality. Snake Hill beds, Snake hill, N. Y.

Remarks. This bryozoan forms a network so delicate that it is just barely visible with the naked eye. The cells are all longer than wide and form a continuous layer on the shell; they radiate from a number of starting points, being apparently composed of different confluent colonies. The corners of the cells are mostly slightly thickened and in some places elevated into distinct tubercles.

Spatiopora sp.

The compressed cephalopod shells in the Utica and Canajoharie shales are very frequently covered by a parasitic bryozoan growth which has in former papers been referred by the present writer to

Sagenella ambigua Walcott. According to information from Doctor Ulrich, these growths represent one or more species of Spatiopora, Sagenella ambigua being one of them. A different incrustation on a cephalopod from the Snake Hill beds is above described as Paleschara ulrichi.

Lingula rectilateralis Emmons

Pl. 4, fig. 1

This species which was originally identified by Hall with L. quadrata Eichwald occurs in good specimens in the Schenectady beds at the Dettbarn quarry at Schenectady and at Rexford Flats. Hall cited the species only from the middle and upper Trenton, but according to Schuchert it ranges from the Trenton into the Lorraine.

Orbiculoidea tenuistriata (Ulrich)

Pl. 4, fig. 2

A single specimen of this species was found at the top of the Frankfort shale in the Frankfort gulf. It has been identified by Doctor Ulrich with his species described in 1878 (Jour. Cin. Soc. Nat. Hist. I, p. 96, pl. 4, fig. 10) from beds of Covington, Ky.; that are now referred to the middle part of the Eden group of the Cincinnati region.

Plectambonites sericeus (Sowerby) **typus**

Pl. 4, fig. 3–6

The Snake Hill shale at Snake hill contains a possible but local variety of Pl. sericeus which markedly differs from the currently accepted expression of this extremely variable species in possessing a well-defined mesial fold on the pedicel valve and a corresponding sinus on the brachial valve, as shown in the specimens here reproduced. In other features, notably the general outline and surface sculpture, the specimens do not appear to differ from the general aspect of the species. While we have found this feature neither figured nor described of any of the American representatives of the species, Sowerby's original figures in "Siluric System" exhibit the same outline and relative size as our Snake Hill variety

and clearly also suggest the presence of the mesial fold. Since Sowerby's types were from the Caradoc of Shropshire, they may be of the same age and identical. For that reason we have designated this particular expression of the species as typus; should it be found, however, that the Shropshire and Snake Hill specimens are both local forms, and hence developed independently of each other, those from Snake hill would have to be distinguished by another name, (var. jugata).

Plectambonites centricarinatus nov.

Pl. 4, fig. 7

The Indian Ladder beds have afforded a rather small type of Plectambonites that is distinguished from the other members of the genus by several peculiar features. The most important of these are the presence of a fold on the pedicel and of a mesial sinus on the brachial valve, the sinus in turn bearing a sharp mesial rib; another is the prominent cardinal wrinkles. It has the mesial sinus and fold in common with a variety of P. sericeus from Snake hill. The small Indian Ladder type is no longer referable to P. sericeus as a variety, its general form being relatively longer and the valves flatter. This species, in common with P. sericeus var. asper James, from the Rysedorph Hill conglomerate (title 48, page 18) has the cardinal folds, the tendency to less unequal radiating lines than in the typical P. sericeus and also the acute cardinal angles. Doctor Ulrich has meanwhile pointed out to me that the Rysedorph Hill and James varieties are different. The Indian Ladder form is allied to the Rysedorph Hill variety by the features mentioned and to the P. sericeus from Snake hill in the mesial fold and sinus.

Plectorthis sp. cf. **whitfieldi** (N. H. Winchell)

Pl. 4, fig. 8

A single valve was obtained in the sandy shale of the Snake Hill beds at Snake hill which while agreeing in the surface sculpture with the form here described as Plaesiomys retrorsa, differs greatly in the outline and convexity of the valve. As sug-

gested to me by Doctor Ulrich, it may possibly be the ventral valve of a Plectorthis, like P. whitfieldi (N. H. Winchell). The costae are remarkably sharp, separated by intervals of equal width; they increase twice by interplantation and number forty-six along the margin. Concentric striae are seen in the intervals. The original is an impression on a slab and the marginal parts may not be entirely preserved and hence the outline not as figured.

Plaesiomys retrorsa (Salter)

Pl. 4, fig. 9–12

The Snake Hill beds contain at Snake hill and in other localities large orthid shells, which however in the shales are always badly crushed and flattened. The gritty sandstone and conglomerate beds at Snake hill have afforded some excellently preserved specimens which are here reproduced. These latter show the characteristic features of Salter's P. retrorsa in outline and especially in the retrorsion of the umbo of the pedicel valve and the forward inclination of the cardinal area of the pedicel valve which latter feature distinguishes this species from the closely related P. porcata (see title 5, page 136). The surface sculpture corresponds to that of P. retrorsa as described by Billings (loc. cit.), Meek (title 6, page 93) and Cumings (title 57, page 902). It consists of sharp ribs (about fifty or more along the margin) that increase by intercalation on the brachial valve but are nearly straight on all parts and increase by bifurcation on the pedicel valve. Closely arranged fine concentric lines are seen in the interspaces while the ribs are smooth or but obscurely marked.

The hinge of the brachial valve which hitherto has not been observed, is reproduced in figure 10. It is not essentially different from that of P. loricata figured by Hall and Clarke (title 18, plate 5A, figure 33) and very remarkably like that of Hebertella sinuata figured *ibidem*. A larger valve (plate 4, figure 13) has the characters rather of P. porcata McCoy (see title 5, page 135) than of the closely related retrorsa. Both P. retrorsa and P. porcata occur also in the Trenton limestone at Ottawa; the appearance of these European species in the Snake Hill beds is therefore not a strange feature.

Clitambonites americanus (Whitfield)

Pl. 4, fig. 14–19

The Snake Hill beds furnished several specimens of a Clitambonites that in general aspect resembles Clitambonites diversus (Shaler). Since in the Ohio basin, however, several similar species have been distinguished, we have sent our specimens to Dr August F. Foerste of the Kentucky Geological Survey, who has kindly given us the following brief sketch of the Kentucky species:

In Kentucky, we have three species of Clitambonites. The lowest of these occurs in the Perryville bed. This is characterized chiefly by the great number of rather fine radiating striations; and the relatively greater width of the shell, compared with Clitambonites diversus. In your specimens the striations are coarser than in these Kentucky specimens, and the shell is narrower.

The second horizon occurs in the upper part of the Winchester, Cynthiana, or Catheys horizon (various names for the same set of strata). This species is not well understood. It contains radiating striae about as coarse as yours, but apparently is a smaller, shorter, broader species.

The third horizon is at the base of the Eden, in what I have called the Rogers Gap division of the Eden. To this species I have given the name Clitambonites diversus-rogersensis (title 64, page 323). As far as the coarseness of the radiating striae is concerned, it appears to be about the same as in your specimens. The width of the Kentucky specimens, however, is greater. This is strikingly shown in the case of the brachial valves, in which the ratio of length to width often is as 15 or 16 to 25. In your specimen the dimensions are as 17 to 21.

To me your specimens most resemble Clitambonites americanus Whitfield, an earlier form than any found in Kentucky. In fact, I do not know in what respect your specimens differ from that species.

Of course, you are familiar with Clitambonites diversus. This is one of the larger species, similar to Clitambonites americanus, but with the shell much more strongly convex from beak to anterior margin. Concentric striae are much more constant and conspicuous. The bombiform convexity of the pedicel valve as a rule attracts instant attention. In those specimens of Clitambonites americanus, which I have seen, the antero-posterior curvature is more like that in your specimen.

Clitambonites americanus (Whitfield) was originally described and figured as Hemipronites americanus (title 11, page 243), but referred by Winchell and Schuchert (title

29, page 378) and Schuchert in his Synopsis of the American Fossil Brachiopoda (title 37, page 183) as a synonym to C. diversus. C. americanus was described from the upper Trenton group (Galena horizon) of Wisconsin, and Hall and Clarke (title 18, plate 15A) have figured it from the Trenton of Minnesota. A comparison of our specimens with Whitfield's original description and figures does not appear to bring out any differential characters. The pedicle valve at our disposal appears higher than the original description requires, but it is somewhat laterally compressed and moreover Hall and Clarke (title 18, plate 15A, figures 7 and 8) figure a still higher variety from the Trenton of Minnesota, later separated by Winchell and Schuchert (title 29, page 381) as var. altissima.

Whiteavesia cincta nov.

Pl. 5, fig. 1

Description. Shell small, obliquely ovate, nearly twice as high posteriorly as anteriorly; strongly convex. Hinge line apparently short, extending posteriorly one-third the distance from the beak to the posterior extremity of the shell. Outline passing almost imperceptibly from the hinge line into the oblique well-rounded posterior margin and thence into the more abruptly rounded basal extremity. Basal margin slightly convex, extending obliquely upward. Anterior end apparently short and fairly well rounded. Beak rather prominent, situated between one-fifth and one-sixth of the length of the shell from the anterior extremity; umbonal ridge broad, strongly rounded, very prominent in the upper half, where it is as high as the umbo, then rapidly declining to the posterior extremity. Surface marked by strong, broad, flat concentric folds that appear as elevated bands. On these many fine concentric lines are seen, and very fine raised radiating lines are observable on the cardinal slope. Muscular impressions not seen.

Horizon and locality. Grayish black sandy shale of Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. As Doctor Ulrich has pointed out to me, this species is allied to Whiteavesia cincinnatiensis H. & W., but much smaller and relatively shorter. It also resembles, in our view, W. subcarinata Ulrich, but is less subalate and convex.

The species is apparently rare in the Snake Hill beds, but a single specimen having been collected.

Whiteavesia cumingsi nov.

Pl. 5, fig. 2, 3

Description. Shell of the size of that of the associated W. cincta, but more oblique, thicker or more ventricose, less higher posteriorly (one-third higher than in front) and more elongate. The hinge line is slightly longer, the posterior margin more rounded, the antero-basal margin more distinctly concave, the anterior margin more sharply rounded and the anterior end longer. Beak not as prominent, situated one-fifth of the length of the shell from the anterior extremity; umbonal ridge distinct to posterior margin. Surface lacking the prominent concentric folds of W. cincta, but showing fine concentric lines and a few growth varices. Sometimes also faint postdorsal radii are seen.

Horizon and locality. Common in the olive colored shale at Snake hill, Saratoga county, N. Y.

Remarks. Although a considerable number of specimens were observed on one slab, the specimens are all so much distorted and especially flattened out that they present an entirely different aspect from the normal outline. We have figured also one of these flattened specimens (plate 5, figure 3) to facilitate recognition of the species. Even if the specimen selected as type is a little compressed laterally and therefore too ventricose and elongated, the general outline will not approach that of W. cincta and the characteristic concentric folds of the latter have not been observed in any of the cotypes.

Doctor Ulrich considers this species as being more closely related to W. subcarinata Ulrich (from the lowest Trenton of Minnesota), W. saffordi Ulrich (lower Stones River) and W. cancellata (Walcott). From W. subcarinata our species is distinguished by the oblique outline, the more convex posterior margin and longer anterior end; from W. cancellata by the surface sculpture. W. saffordi is a much older form.

Orthodesma ? subcarinatum nov.

Pl. 5, fig. 5–8

Description. Shells small, elongate, narrow and moderately arcuate, the length from two and one-half to three times the greatest posterior height and from three and one-fourth to three and one-half times the height at the beaks; valves rather strongly convex, culmi-

nating in about the middle of the umbonal ridge. Dorsal and ventral margins distinctly diverging posteriorly, the former straight or but very gently arcuate, the latter with a slight and broad sinus in the middle. Anterior end narrow, produced, the posterior end well rounded and quite convex above the somewhat more abruptly rounded basal part and passing gradually into the hinge line. Beaks not prominent, compressed, about one-fifth of the length of the shell from the anterior extremity; umbonal ridge subcarinate, a very marked feature above and traceable to the postero-basal margin. Mesial sulcus well defined and an obscure broad ridge passing from the beak obliquely forward and downward to the antebasal angle. Surface with irregular undulations and fine intercalated lines. Muscular scars not distinct.

Position and locality. Rather common in a bed of dark gray sandy shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. Doctor Ulrich writes me regarding this species that it belongs to an early group of Modiolopsidae, combining, with some of its own, the characters of Modiolopsis and Orthodesma, adding: "Its nearest ally is O. subnasutum. Another close ally is the Modiolopsis milleri (Cincinnati), a third M. arguta Ulrich (Black River). Several other species of the group which will some day be distinguished generically are figured on plate 36 of my Minnesota report. The Snake Hill species differs from all in its more sharply defined umbonal ridge. None of the specimens retains its original outline. One (plate 5, figure 5) comes nearest the normal." We have used the latter as type of the species and based our description upon this specimen. The specimen (plate 5, figure 7) is clearly too elongate by lateral compression; there occur specimens which possess not half that relative length and are compressed in antero-posterior direction. It also appears to us that O. subcarinatum possesses a more evenly rounded posterior margin than O. subnasutum and is relatively a little higher posteriorly, and is smaller; but otherwise it is hardly distinguishable from the western Galena form.

Prolobella ? trentonensis (Conrad)

Pl. 5, fig. 4

This species was first described as Avicula trentonensis by Conrad (Jour. Acad. Nat. Sci., 1842, 8:240) from the Trenton limestone and shortly after (title 3, page 161) by Hall

as occurring in "the central and higher portions of the Trenton limestone at Middleville, and in the calcareous layers in the Utica slate at Coldspring, Montgomery county, N. Y." It has been found by us to be not uncommon in the Canajoharie beds at Canajoharie and the old locality of Coldspring is in the same formation not far away on the other (north) side of the Mohawk river.

In the Geology of Minnesota (title 38, page 532), Doctor Ulrich states of this species that it is almost certain that it belongs to his genus Prolobella which he places with the Modiolopsidae, and that it does not belong to the true Aviculidae, "their valves being equal and without the prolonged posterior wing."

Whitella elongata nov.

Pl. 5, fig. 9, 10

Description. Shell of medium size, compressed, subrhomboidal, a little wider posteriorly (by about one-fifth), length about three-fifths greater than posterior width, and shell about six times as long as thick. Anterior margin straight or even slightly concave in upper part, probably subangular at the anterior extremity of the hinge (the extremity not preserved); evenly rounded below, postbasal angle not well seen, apparently also strongly rounded, posterior margin very gently convex or gently straight (but partly seen) gradually merging into the dorsal line. Beaks small and little prominent and probably but little incurved, situated about one-fourth the length of the shell behind the anterior extremity; umbonal ridge very sharp at the beginning, possibly through oblique compression of the shell, becoming obsolete before reaching the postbasal margin. Surface gently convex posteriorly to the ridge and rather flat in front and below it. Surface marked by coarser, distant lines of growth and fine intercalated concentric lines. Escutcheon and hinge not seen, muscular scars but faintly.

Position and locality. Olive gray shaly sandstone of Snake Hill (Trenton) beds at Snake hill, Saratoga county, N. Y.

Doctor Ulrich writes me regarding this species that it belongs in the group of W. compressa Ulrich and W. ohioensis Ulrich, but is more elongate. The former species occurs in the Middle Third of the Trenton shales of Minnesota, the latter in the lower Richmond beds of Ohio. We have obtained but a single specimen of this species, which is obviously rare in our Trenton shales.

Clidophorus foerstei nov.

Pl. 5, fig. 15, 16

Hall (title 3, page 301) cites C. planulatus (Conrad) as occurring besides in the Lorraine beds of northwestern New York, also in the altered slates of Waterford, Saratoga county, N. Y., and figures a specimen from that locality (op. cit. plate 82, figure 9e). We have in our earlier work (Bulletin 42) followed that authority in identifying the Clidophorus from the shales of the Hudson valley with the Lorraine form. The better preserved material since obtained at Snake hill has shown however that there are at least two species of this genus present in the Snake Hill beds, one of rather ventricose form, here described as C. ventricosus, and another that comes near to C. planulatus. Hall's above-cited type from Waterford belongs to this second species. As his own figure shows this species is also more ventricose than the C. planulatus although approaching it closely in general outline. By a careful comparison of the Snake Hill specimens with types of C. planulatus from the Lorraine beds, we have ascertained the following differences: the shell of C. foerstei is less elongate, or relatively higher, in C. planulatus the length being two to two and one-half times greater than the height, and in C. foerstei somewhat less than two times greater; while in the former species the ventral slope is very flat, and the shell much compressed, as expressed in the name; that of C. foerstei is more convex, although not nearly so as in C. ventricosus; the clavicle is decidedly shorter in C. foerstei.

Horizon and locality. Snake Hill beds at Snake hill, Saratoga county, and other localities of that formation in Saratoga and Albany counties.

Clidophorus ventricosus nov.

Pl. 5, fig. 11–14

Description. Shell of medium size for the genus or above; transversely subrhomboidal in outline; subalate; with the height a little more than one-half the length of the shell, anterior end rounded and narrower than the posterior one which is obliquely truncate; the ventral margin is rather strongly convex and the dorsal margin straight posteriorly of the beak and declining obliquely forward in front of the beak. The posterior dorsal and posterior ventral

extremities are both subangular, the former obtusely, the latter acutely so; the anterior extremity is abruptly rounded. Beak small, placed about midlength between the anterior and posterior extremities, umbo not very prominent, shell culminating a little above the center; umbonal ridge broad and traceable to the postventral extremity. Anterior, ventral and posterior slopes evenly rounded, cardinal slope slightly concave. "Clavicular"[1] impression closely in front of the beak, broad but not strong, nearly straight, extending obliquely forward and downward about one-third the distance to the anteroventral margin. Near the post-dorsal angle are seen (see plate 5, figure 13) small oblique hinge denticles or ribs that are found among Ordovicic forms only in Clidophorus. Muscular impressions not observed. Surface with several coarse varices of growth and fine, very regular concentric lines which are barely visible with the naked eye.

Horizon and locality. Not uncommon in the dark gray to olive colored sandy shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. This species is readily distinguished from C. planulatus (Conrad) by the much greater convexity of the shells. Doctor Ulrich writes me regarding the same that it shows the beak nearer midlength than it is in any described species; that it is most like an undescribed type from the Southgate division of the Eden at Cincinnati, and that it may be the same as one in the basal part of the Martinsburg shale in Pennsylvania, the specimens of which however are not good enough to decide the matter. The general form is as in Whiteavesia but the characteristic Clidophorus clavicle and the small oblique hinge denticles are present.

Ctenodonta levata (Hall)

Pl. 6, fig. 1

We have cited under this name certain small Ctenodontas from the sandy shale of the Snake Hill beds at Snake hill and elsewhere. Of the specimen figured Doctor Ulrich writes us that he

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[1] This impression is currently termed the *clavicular impression*, but it is obvious that it does not result from the prop or buttress, called *clavicle* in more recent forms, which serves to reinforce the attachment of the resilium or lower ligament. The "clavicle" of Clidophorus is a buttress or lamina which by its position is clearly intended to support the anterior adductor. Its relation to that muscle is well shown in our plate 5, figure 15. The more recent Cucullaea, to cite an analogous case, possesses a like radial buttress for the support of the posterior adductor.

can not distinguish it from specimens from Sacketts Harbor and the writer has taken occasion to compare it with some of Hall's types in the American Museum of Natural History. C. levata is a middle Trenton species; it has been cited from our Utica shale and other higher formations but probably erroneously.

Ctenodonta declivis nov.

Pl. 6, fig. 2, 3

Description. Shell small, acuminate, subovate, height by one-fifth greater than the length, basal margin well rounded, nearly semicircular as in C. obliqua, anterior dorsal margin slightly concave, posterior dorsal margin convex. Beak prominent, situated a little anterior of the center, curved backward; umbonal ridge broad and little prominent, surface sloping gradually forward and more abruptly backward, shell moderately convex, culminating anteriorly of the center. Surface with faint growth lines. Interior characters not observed.

Position and locality. Olive gray, sandy shale of Snake Hill beds, Snake hill.

Remarks. C. declivis is in size and form closely allied to C. obliqua (Hall), a species that is found in all groups of the Cincinnati period. It differs from that species in being higher and having the beak more anteriorly, but may in a revision of the Ctenodontae be found to be but an earlier mutation of that long ranged Western form.

Ctenodonta prosseri nov.

Pl. 6, fig. 4, 5

Description. Shell small, moderately convex, broadly obliquely subtriangular, well rounded in front and broadly rounded below, narrow behind, with fairly large, prominent, incurved beaks, directed posteriorly and situated a little anteriorly (about one-seventh of length) of the middle; umbones carinate behind, the ridge slightly concave in a side view. Hinge not seen.

Position and locality. Snake Hill beds at Snake hill and other places in Saratoga and Albany counties, N. Y.

Remarks. Doctor Ulrich has pointed out to us that this species is closely allied to his species C. scofieldi (title 39, page 593) from the Trenton and Galena shales of Minnesota. Our species

would seem to differ from the western form mainly in the somewhat more elongate form, the less evenly rounded anterior and posterior margins and the more posterior position of the beak.

Ctenodonta radiata nov.

Pl. 6, fig. 6

Description. Shell thin, of medium size, subovate, three-fourths as high as long, anterior margin broadly rounded, posterior oblique and nearly straight or gently convex in the dorsal part and rather sharply rounded below; the ventral margin is but slightly curved. Beaks very little prominent, situated a little more than one-fourth of the entire length behind the anterior extremity. Shell compressed-convex, more convex in posterior half, culminating posteriorly of center in the broadly rounded umbonal ridge. Surface markings consisting of a few growth varices and fine concentric lines, which are crossed on the posterior portion by straight radiating lines. Hinge and muscle scars not observed.

Position and locality. Dark gray to olive, partly sandy shales of Snake Hill beds, Snake hill, Saratoga county, N. Y.

Remarks. This is one of the largest Ctenodontas of the Snake Hill beds; it is readily distinguished from the others by its size, the thinness of its shell and above all the radiating lines. These latter, as several other characteristic features, it has in common with C. calvini Ulrich, a western Richmond (Maquoketa) species. It differs from that younger species in being relatively shorter, narrower behind and higher in front.

Ctenodonta recta nov.

Pl. 6, fig. 7, 8

Description. Shell small, compressed, convex, subtriangular in outline, one-third longer than high; beak rather large but little prominent, incurved, turned slightly backward, situated about midway between the extremities; anterior margin well rounded, posterior more abruptly, and ventral one broadly. Anterior dorsal margin slightly convex, posterior one distinctly concave, impressed so as to form a small lunette. Surface of shell almost uniformly convex, highest subcentrally; with a few well-marked varices of growth and fine concentric lines. Hinge plate and muscular scars not observed.

Position and locality. In the dark sandy shale of the Snake Hill beds at Snake hill and elsewhere.

Remarks. This small type appears to us to be most similar to C. medialis Ulrich among the western Trenton forms, with which it has the general outline and the position of the beaks in common. Our species is, however, more elongate and possesses a more convex anterior margin.

Ctenodonta subcuneata nov.

Pl. 6, fig. 9, 10

Description. Shell below medium size, compressed, only about one-eighth longer than high, and about one-eighth as thick as long, acuminate subovate in outline; umbones fairly prominent and beaks incurved, directed distinctly forward and situated between one-third and one-fourth of the length behind the anterior extremity; posterior and anterior ends about equally wide, anterior dorsal margin oblique, slightly concave, posterior dorsal slope slightly convex, postero-basal part well rounded and basal margin broadly rounded. Umbonal ridge broad and distinct only in umbonal region. Surface marked by a few varices of growth and fine concentric lines. Posterior muscle scar faintly seen. Hingle plate not seen.

Position and localities. In dark gray sandy shale of Snake Hill beds, Snake hill, Saratoga county, N. Y.

Remarks. This species is easily distinguished from the associated congeners by its rather high relatively flat shell. According to a note from Doctor Ulrich it is allied to the western Richmond species C. fecunda (Hall). It is relatively higher and less extended posteriorly than the latter.

Allodesma subellipticum Ulrich

Pl. 6, fig. 11

The Canajoharie shale above the falls at Canajoharie has afforded several specimens of a small thin-shelled pelecypod that are much flattened and fail to show any structure. Doctor Ulrich has referred them doubtfully to his Allodesma subellipticum, a species from the Galena shales of Minnesota.

Lyrodesma schucherti nov.

Pl. 6, fig. 12

Description. Shell elongate-ovate, twice as long as high, greatest height a little anterior to middle; anterior part drawn out, posterior one obliquely truncate; shell rather flat, greatest thickness subcen-

tral; cardinal margin nearly straight or slightly declining each way from beak; anterior margin abruptly rounded, basal margin broadly and evenly rounded, posterior basal angle subacute, posterior margin gently convex, passing obliquely upward and forward to the obtusely and obscurely angular posterior cardinal extremity. Beak apparently small, situated fairly midway between the cardinal extremities, umbo not very prominent; umbonal ridge sharply angular. Anterior slope rounded, with a flattening of the nasute anterior extremity; ventral slope evenly rounded; posterior slope concave along the umbonal ridge, abruptly turning into the flat nearly vertical posterior cardinal slope. Surface of anterior and ventral slopes almost smooth, only faint, widely separated growth-lines being visible; the posterior slope bears five sharp radiating ribs and the posterior cardinal slope one or two obscure flat ribs.

Horizon and locality. Very rare (only one specimen found) in dark gray sandy shale of Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. This species is similar in form and size to the shell from the Trenton of Carlisle, Pa., which Hall had referred to the Lorraine species Nuculites poststriata Emmons (title 3, page 151). Ulrich (title 38, page 610) has pointed out that the Trenton Nuculites (now Lyrodesma) poststriata and the Lorraine form are not identical, and has referred the Trenton species with some doubt to his Lyrodesma cannonense. Our species is clearly more elongate than any of these. Doctor Ulrich writes me regarding this species: " Though of the same section of genus, this is not the same species as either of the two Lorraine species that are current under the name L. poststriatum. My Black River L. acuminatum is also one of this section and even nearer. The broader and more common of the two Lorraine species to which the name poststriatum should be restricted, would seem to be a larger shell than this Snake Hill species. The latter is not only smaller but is relatively lower (from beak to ventral margin), relatively wider posteriorly and less strongly convex in the ventral part of its outline."

Hall (op. cit. page 302) cites also Lyrodesma pulchella, a species which typically occurs in the Lorraine beds at Pulaski, as occurring in the " black glazed slates near Waterford " and figures (plate 82, fig. 12c) a small specimen from that locality. Since we now know that the shales about Waterford are all of Trenton age, being partly Canajoharie and partly Snake Hill shales, it is

an *a priori* inference that this small specimen is no longer referable to S. pulchella. A comparison of the figures of the Pulaski type (plate 82, figure 12a) and of the Waterford specimen (12c) shows marked difference in the position of the umbo and the general outline. The latter belongs apparently to one of the small Ctenodontas described from the Snake Hill beds; at any rate it is not identical with the L. schucherti here described.

Solenomya ? insperata nov.

Pl. 6, fig. 13, 14

Description. Shell rather small, very elongate, narrowing anteriorly, its length three times its height, greatest height one-sixth the length from the posterior margin; little convex; the greatest thickness not quite one-fourth the height. Umbones little prominent, situated very posteriorly, one-eighth the length of the shell from the posterior extremity; beaks apparently small and projecting slightly above the hinge. Cardinal and basal margins straight, converging gradually anteriorly; posterior margin slightly concave above and nearly vertical in the lower half; anterior margin evenly rounded. Umbonal ridge distinct and sharp, the anterior slope evenly rounded in the posterior part and becoming rather flat in front; the posterior slope steeply oblique, concave above (apparently with an elongate elliptic area) and flat below. Surface with irregularly spaced concentric folds which are most prominent on the anterior slope and the umbonal ridge and numerous fine concentric raised lines between and upon the folds.

The interior characters have not been seen, no casts of the interior having been obtained.

Position and locality. Rare (but four specimens collected) in the sandy mud shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. Doctor Ulrich writes me regarding this remarkable pelecypod that its relations seem to be with Solenomya or Clinopistha — both Devonic and Carbonic genera — rather than with any Ordovicic shells known to him, the short end seeming to be the posterior, and he suggests that the species belongs to Solenomya or a new genus. As far as the shale material permits of observation, the beaks are inclined toward the longer end of the shell, corroborating Doctor Ulrich's inference. Since our material does not give any clues to the interior characters and there are no important feat-

ures apparent that would distinguish the form from Solenomya, we have, for the present, left the species with that genus. If this reference is correct, the species is the first representative of the Solenomyidae in the Ordovicic.

Cuneamya acutifrons Ulrich

Pl. 6, fig. 15, 16

In the olive and dark gray sandy shales of the Snake Hill a species occurs which has been identified by Doctor Ulrich with a form from the lower Trenton at Cincinnati, known to him since 1880 and in manuscript since 1886. Doctor Ulrich's description kindly sent to us at our request is as follows:

Description. Shell exceeding medium size for the genus, moderately convex, with the point of greatest convexity near the middle; outline transversely elongate, subovate or subrhomboidal, prowlike

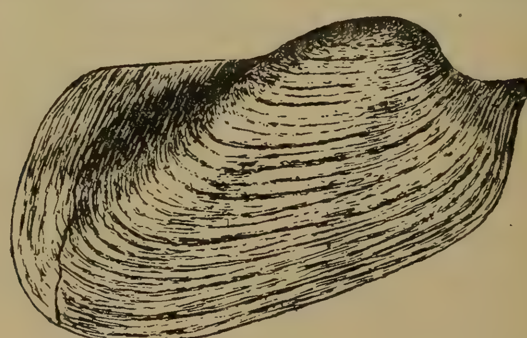


Fig. 30. Cuneamya acutifrons Ulrich.

Holotype. Natural size.

in front, highest in posterior half, narrowing anteriorly to the sharply produced antero-dorsal extremity; umbones large, prominent, the beaks strongly incurved and situated well forward; antero-dorsal edge subparallel with, but appreciably lower than, the hinge line, inflected so as to form a narrow, almost linear, lunule; anterior margin trending backward from the sharp dorsal extremity in a gently sigmoid curve to the ventral side; ventral edge nearly straight, with a barely suggested sinuosity in front of the middle; posterior margin somewhat truncated, moderately oblique, sharply rounded where it joins the dorsal line and more broadly curved in the lower third; dorsal edge nearly straight, the part visible in a side view behind the umbones equaling in length about one-third, the whole to the apices of the beaks rather more than one-half, of the greatest length of the valves; escutcheon very narrow and shallow. Posterior umbonal ridge prominent, rounded, with the slope to the cardinal margin rapid and slightly concave. Two undefined furrows

or sulci are present on the anterior third of the valve; one, very narrow, between the anterior umbonal ridge and the nasute anterior projection; the other running obliquely backwards from the anterior side of the umbones, to the basal margin, where it produces a slight sinuosity. Surface marked with irregular concentric wrinkles, which are generally most prominent over the more gibbous parts of the valve.

Length of best specimen seen, 2.4 inches; greatest height, measuring vertically across the anterior end of the posterior third, 1.15 inches; from a point back of umbones to basal margin, 1 inch; from highest point of umbones to antero-basal portion, 1 inch; length of nasute extension of anterior end, from its extremity to the anterior side of umbones, .38 inch; convexity of one valve, .5 inch.

This species differs from the typical forms of this genus in that the posterior half of the valves is much wider (higher) than the anterior. The generic reference is probably only temporary pending a revision of the shells of this family. Of described species only C. scapha Hall and Whitfield, bears any resemblance. The new species is readily distinguished by its greater width posteriorly, greater convexity, more prominent umbones, smaller lunule, much more acute and prolonged anterior end, less distinct mesial sulcus, and somewhat different surface markings. Closer allies are found among the undescribed species in the Ulrich collection at the United States National Museum.

Formation and locality. This species is rare, and hitherto has been found only in association with Whiteavesia cincinnatiensis (Hall and Whitfield) in a limestone bed exposed in the banks of the Ohio at Covington, Ky. This bed lies near the top of the Bromley shale, a formation corresponding very nearly to the Hermitage formation of middle Tennessee and central Kentucky. Correlating with New York formations its age would be early Trenton.

Holotype. U. S. Nat. Mus. Cat. no. 47314.

Doctor Ulrich observes that the Snake hill specimen is smaller and somewhat shorter, the latter perhaps due to pressure, but otherwise undistinguishable from the Cincinnati specimens.

Saffordia ulrichi nov.

Pl. 6, fig. 17, 18

For a great many years there has been in the State Museum a large fossil shell which had been sent in from one of the "bluestone" quarries at Schenectady[1] and which was considered as a

[1] It is labeled: "Hudson River group, from Schenectada, near the College. From J. L. Coon."

problematicum. On being worked out it proved to be a large lamellibranch and this has been identified by Doctor Ulrich with his genus Saffordia. A second more fragmentary specimen obtained a year ago by the writer in a bluestone quarry between Schenectady and Aqueduct verifies the actual occurrence of the species in the Schenectady sandstone.

Description. Shell large, transversely subovate, the height and length nearly as five is to seven. Dorsal margin nearly straight, very gently convex, anterior margin distinctly concave in upper part and moderately convex in the lower; the ventral and posterior margins form one very strongly and evenly rounded curve. Beaks subterminal, declining forward, strongly incurved, projecting forward nearly as far as the anterior extremity of shell; umbonal ridge very inconspicuous; angular along the dorsal edge. Probably a narrow sulcus on the dorsal slope; ventral and anterior slopes depressed convex. Escutcheon and lunule suggested but not clearly preserved in the type specimen. Surface marked with strong concentric folds that are most prominent in the upper half and become fainter on the umbonal ridge and along the anterior and ventral margins. Internal characters not observed.

Position and locality. In the sandstone of the Schenectady shale at Schenectady.

Remarks. This species differs by its dimensions from all other Saffordias, which are distinguished by their rather small size. In its general outline, the characters of the beak, etc. it most resembles S. ventralis Ulrich, a Richmond species of Minnesota and Wisconsin.

Archinacella orbiculata (Hall)

Pl. 7, fig. 1–6

Hall (title 3, page 306) has described as Carinaropsis orbiculatus a small patelloid gastropod from the " slates of the Hudson River group, near Waterford," which has been obtained by us in the Snake Hill beds of Snake hill and other localities, among them also the contorted shales near Waterford, N. Y. The original description of this species reads as follows:

> Suborbicular, apex subcentral, small, slightly inclined; surface finely striated. This species has the form of Orbicula, but the apex is remarkably elevated and no flat valve has been observed.

A comparison of the two type specimens kindly loaned to us by Dr E. O. Hovey, with the description and the original figures (op.

cit. plate 83, figures 8a, b, c) shows that owing to the preservation of the specimens the description and original figures are misleading, and the latter quite incorrect. We have for this reason refigured these types (plate 7, figures 3–6). The apex is broken off in both specimens and the scars of the beaks and the growth lines show that the apex was not subcentral as described, but situated well forward. One specimen (type 8a) is obviously flattened and the other much compressed laterally, as shown by the crest and hence too elongate and high. The surface is nearly smooth and exhibits only obscure finer and a few coarser growth lines. From the type specimens and others from Snake hill we have derived the following description of the species:

Description. Shell small, broadly subovate in outline, length not quite one-fifth greater than width, slightly wider in front than behind, obliquely subconical, apex situated about one-sixth of the length from the anterior margin, apex hardly incurved, apertural margin arched. In profile view moderately concave below the apex and gently convex behind. Surface markings consisting of fine growth lines and some deeper impressed lines near the margin. Length of type (plate 7, figure 3) 7.5 mm; width (too great) 6.2 mm; height 2.0 + mm.

Horizon and locality. Snake Hill shale at Snake hill and other localities in Saratoga and Albany counties.

Remarks. Hall (title 3, page 306) cites his species C. patelliformis, which is typically based on specimens from the Trenton limestone, also from the "semialtered shales near Waterford" without, however, figuring specimens from that locality, his "Hudson River" type (plate 83, figure 7) coming according to Whitfield and Hovey's Type-catalogue (page 50) from Pulaski and being hence a Lorraine type and quite obviously a species different from Archinacella patelliformis. The Waterford specimens differ from A. patelliformis of the Trenton limestone in the profile, the anterior line being much deeper cut in the latter species and the apex more protruding and also situated a little more forward; and in the presence of distinct concentric surface lines in that species. Our specimens of A. orbiculata from the Snake Hill beds are all somewhat laterally compressed, as shown by an irregular carina on the posterior slope, but they show quite clearly that this species was wider in front than in A. patelliformis and that probably it is allied to A. deleta Sardeson as figured by Ulrich and Scofield (1897, plate 61, figures 16–20).

Cyclonema montrealense Billings

Pl. 7, fig. 7

The gritty sandstone bed of the Snake Hill formation at Snake hill has afforded the impression of a small Cyclonema which has the characters of C. montrealense from the Trenton limestone of the island of Montreal. It agrees especially with that species in having the whorls "moderately ventricose, most prominent in the lower half," a rather deep suture, in the character of the spiral lines, of which there are about ten in 4 mm with one or two smaller ones between each pair of the larger lines. The spire is somewhat higher than Billings's description (title 4, page 30) and figure require, but since Ulrich (title 39, page 1059) after an exhaustive study of the western Cyclonemas states that the relative height of the spire is a very unreliable character, and that the form of the whorls is a better character, but that the surface markings have served him best of all in separating the various species, we do not feel warranted in attaching much importance to this difference in the spires.

Cyclonema cushingi nov.

Pl. 7, fig. 8–10

We had repeatedly observed fragments of a gigantic Cyclonema in the Snake Hill beds at Snake hill, but owe the fairly perfect specimen here figured to the collecting spirit of Prof. H. P. Cushing to whom we gladly dedicate this species in recognition of the fact that he does not disdain to be interested in fossils.

The specimens at hand are too badly crushed to allow a description of the species, but since the form is obviously closely allied to C. hageri Billings (1865, page 29), a Trenton form from Montreal island, it seems best to define this new species with the latter by determining its differences from the Canadian relative. The Snake Hill type has in common with the latter the large size and the number of whorls (about four). Also the form of the volutions appears to agree, the upper ones being rather flat or somewhat depressed in the middle, while it is not certain, whether the last volution was as ventricose as in C. hageri, or became concave in the type specimen through being crushed. We believe the latter on account of the presence of the oblique folds and a protruding lower rim in the specimen which indicate a former greater expansion of that volution. The apical angle is apparently less than in the other

species, but the evidence in regard to this character is not conclusive. The surface sculpture exhibits revolving lines which are markedly closer arranged than those of C. hageri, where they are from one to two millimeters apart, while here the larger ones are one millimeter apart, but contain a smaller one between them. C. hageri possesses "strong angular ribs or undulations of growth from half a line (1 mm) to two lines (about 4 mm) apart becoming more prominent with age. The Snake Hill form has on the older volutions closely arranged subequal growth lines, which on the last volution become gathered into elevated bundles of lines, the middlemost of which are thicker and broader than the others. The high folds on the type specimen are largely due to the lateral compression of the shell.

It will be noticed that our species stands in its characters between C. montrealense and C. hageri. The form from the Jacksonburg limestone of New Jersey referred by Weller (title 53, page 186) to C. montrealense, has also its revolving lines farther apart than the Canadian type of that species and more convex volutions, and may represent a fourth expression of the same group. Its revolving lines are of the character of those of C. cushingi.

Hyolithes pinniformis nov.

Pl. 7, fig. 12, 13

Shell small, slightly bent in proximal portion, expanding somewhat rapidly, one side flattened or slightly convex, the other with a blunt median keel. The flat side is longer, projecting with an evenly rounded lobe beyond the aperture, while the keeled side forms a blunt reëntrant angle. The surface is furnished with closely arranged sharp arching transverse striae (growth lines, which are most distinct on the flat side; and with fainter longitudinal lines. Operculum not observed.

Horizon and locality. Canajoharie shale at Canajoharie, N. Y.

Remarks. This species belongs to the group of Hyolithes s. str. in distinction from the subgenus Orthotheca, Novak, according to the character of its aperture. It is distinguished from the other Trenton species of Hyolithes, save H. baconi Whitfield, by its more robust form. The latter species, from the Trenton of Wisconsin is considerably larger and the apertural lobe of the flat side is less projecting.

The type specimen (plate 7, figure 12) measures 13.5 mm in length and 4 mm in width. It shows a distinct, very concave septum in the apical portion. Our specimens are so flattened that their section can not be conclusively determined. It seems to have been elliptical with one side angular.

Orthoceras arcuolineatum nov.

Pl. 8, fig. 1, 2

Slender, small orthoceracone, increasing at the rate of .5 mm of diameter in length of 10 mm. Section elliptic, nearly circular, the minor and major diameters as 7.1 to 7.5 mm. Camerae shallow, nearly four times as wide as deep. Septa closely arranged, about 2 mm apart where the diameter of the conch is 7 mm deep, their depth approximately corresponding to that of the camerae. Sutures arching slightly up on one side. Living chamber not known. Siphuncle centren, small, about one-seventh the diameter of the conch; segments cylindrical, the funnels short and straight. Ornamentation consisting of relatively widely separated (about 2 in 1 mm) sharp raised transverse lines, or ridges, which are intersected by extremely fine longitudinal lines. The transverse lines are strongly bent upward on one of the narrow sides of the conch.

Horizon and locality. Canajoharie shale at Ford Edward, N. Y.

Remarks. This species is based on only the small fragment that is figured here. This shows, however, especially in the ornamentation, characters that distinguish it from other Trenton species known to us. It is apparently, from the character of the siphuncle, a true Orthoceras.

Orthoceras hudsonicum nov.

Pl. 8, fig. 3–10

Small to medium sized, slender, slightly curved cone, with closely arranged septa and subcentral, narrow siphuncle. The cone widens so gradually that in a distance of 50 mm it expands from 5 mm to 10 mm or less (measured in compressed specimen). The septa equal in depth the chambers; they are closely arranged, about 2 mm apart, where the conch is 7 mm wide; the sutures are straight transverse. The siphuncle is centren, wide, about one-third the width of the conch, the funnels apparently short and straight. The living chamber and aperture have not been observed. The nepionic conch possesses only fine longitudinal striae, of somewhat irregular char-

acter, and the mature conch transverse sharp striae, about four to the millimeter; the neanic conch exhibits an intersecting system of both, visible to the naked eye, while on the mature conch still shadowlike traces of the longitudinal lines are visible under the lens.

Formation and locality. In the Canajoharie shale at Alplaus creek, Saratoga county, N. Y., and other places.

Remarks. This species is easily recognized by three characters; its slender, slightly curved shell, the closely arranged septa and the delicate surface sculpture.

The specimens are all more or less crushed, and the septa mostly dissolved and the conch filled with shale. We have, therefore, been unable to satisfy ourselves completely as to the generic determination of the species, and we do not know whether it is a true Orthoceras or not. On account of the relative width of the siphuncle it approaches Baltoceras.

The surface sculpture corresponds exactly to that of Endoceras proteiforme var. tenuitextum, var. tenuistriatum and lineolatum Hall, as described in Palaeontology of New York, volume 1. These Trenton forms do not belong to Endoceras proteiforme but are orthoceratites that need revision. Also the common and often cited "Endoceras proteiforme" of the Utica slate (title 3, plate 85, figure 1) belongs in the same group which eventually will be referred to, we believe, as Orthoceras tenuitextum Hall. They all have the same rate of growth, the same closely set septa and the same characteristic surface sculpture. We would also have referred the species here described to Hall's species if it were not for the curvature of the conch.

A species identical with our type save its coarse cancellated sculpture, has been described by Walcott (title 9, page 22) as O. oneidense from the Utica shale of Trenton, N. Y.

The most interesting feature of the material from the Alplaus creek is the presence of the embryo shells or protoconchs on the partly pyritized and partly calcified nepionic portions of the conchs (see plate 8, figures 4, 5).

The history of the investigation of the protoconch of the orthoceratites is a very interesting one. Branca considered as the embryonal shell or protoconch the cup-shaped termination of the conch as usually found. Hyatt viewed this chamber as the first chamber and the cicatrix which it generally bears upon its distal surface as the remnant of the protoconch. The latter was figured by

him in the *Genesis of the Arietidae* as a very small, shrunken wart-like appendix, the aspect of which was explained by assuming it to have been composed of conchiolin, which also accounts for its almost invariable absence. In 1893 Clarke (title 20, page 112) announced the discovery of a small fragment of an Orthoceras conch from the Devonic of New York that retains a good-sized calcified protoconch. This minute and interesting specimen was found in the same geological horizon (Styliola-limestone) with protoconchs of Bactrites and distinguished from them by the central position of the siphuncle. The very similar protoconchs and early stages of Bactrites were first described by Clarke in a subsequent paper (title 23, page 37) and more fully in the first part of the Memoir on the Naples Fauna (page 122). Hyatt in his *Phylogeny of an Acquired Characteristic* assumes regarding the protoconch of that Orthoceras the stand that this " form certainly has the characters of an Orthoceras, but the protoconch is large and like that of the Ammonoidea. The shell may be transitional from Orthoceras to Bactrites, but it is probably not a typical form of Orthoceras." This view which gives the small fragment from the Styliola limestone still greater phylogenetic interest, was later (op. cit., page 130) concurred in by Clarke, who considers it " conceivable that such differences as are here indicated by the young [of Orthoceras and Bactrites] may be totally extinguished in the later growth stages so that the mature form of the species in question may be before us, though present knowledge does not enable us to recognize it." Even if the unique small shell described by Clarke represents but a transitional form, it demonstrates that there must exist true Orthoceras with like large calcareous initial chambers. Indeed such were found not long after by Pocta.

In 1902 Pocta (title 50) published a note on the initial chamber of Orthoceras, his observations being based on the sections of diabas tuffa of the band e_1, of the Bohemian Upper Siluric. These sections showed clearly the presence of a baglike protoconch in both longiconic and breviconic orthoceratites, the species of which, however, could not be determined. Pocta obtained the following conclusions:

1 The genus Orthoceras possessed a calcareous initial chamber.

2 The form of the same was baglike, somewhat contracted downward, but always of greater width than the first air chamber.

3 This protoconch exists only in juvenile stages, later it is absent, and its traces in mature individuals are extremely rare (Clarke).

4 The first siphonal funnel was collarlike reflexed and thus formed the scar (Barrande's "cicatrix"). This first siphonal funnel has as a rule a different shape from that of the other funnels of the conch.

Our material consisted only of about half a dozen protoconchs which, however, were large enough (1.6 mm wide) to be broken out and in two instances made into thin sections. Both the exterior view and the sections verify Pocta's observations as to the width of the protoconch being greater than the first camera and the reflexed character of the first funnel. It will be noticed that in O. hudsonicum the volume of the protoconch corresponds approximately to that of the first camera.

This is the first observation of the protoconch of an Orthoceras in the Lower Siluric, Doctor Clarke's specimen coming from the Devonic and Professor Pocta's from the Upper Siluric. The different character of the nepionic conch of Endoceras has already been described by Holm in 1885 (Pal. Abh. von Dames and Kayser, volume 3, and Geol. Fören. i Stockholm Förhandl. 1896, volume 18). The protoconchs of orthoceratites are by no means rare in the Utica shale, for we had already obtained a large series of pyritized specimens at Dolgeville some fifteen years ago. These, however, were lost in transportation and the bed has become inaccessible by the building of a dam. The Dolgeville material was the same or a very closely related species.

Oncoceras (?) sp.

Pl. 8, fig. 12

A completely flattened specimen from the Canajoharie shale at North Albany. Its condition does not allow either a definite generic determination or a sufficient specific diagnosis. The living chamber was short and the apertural portion somewhat contracted; the aperture apparently regular and circular. The septa are seen only faintly, they were closely arranged and arched on both the ventral and dorsal sides. The siphuncle is very indistinct, apparently with straight segments. The form seems to be distinct from the other Trenton species of Oncoceras but would not warrant being named.

Conularia trentonensis var. multicosta nov.

Both the Schenectady and the Snake Hill beds have furnished specimens of a Conularia which possesses the characteristic apical angle (18°–20°) and sculpture of C. trentonensis, i. e. a system of transverse ridges crossed by closely set longitudinal bars,

with the difference, however, that the sculpture is much finer in the shale variety, the ridges and bars being just about twice as closely set and correspondingly lower than in the trentonensis (15 to 17 ridges in 5 mm as against 6 to 9 in C. trentonensis). This difference having been found to be constant in all specimens observed in the shale (Snake Hill beds at Watervliet and the Schenectady beds at Schenectady and Schoharie Junction), it becomes necessary to recognize it as of at least varietal importance. We therefore propose to distinguish this form as var. multicosta.

It represents the other extreme of variation to the type described by Emmons (Amer. Geology, 1:208) as C. hudsonia from the Lorraine beds at Lorraine, N. Y., which latter form exhibits the trentonensis-sculpture about twice as coarse as the Trenton type.

A fragment of a specimen from Watervliet retains part of the apertural lobe. The sculpture on this consists of the transverse ridges which are much more crowded than on the lateral faces of the shell and sharply bent forward in the middle.

Eoharpes ottawensis (Billings)

Pl. 9, fig. 1

A single specimen found in a loose slab of Snake Hill shale on Snake hill, represents thus far this Canadian species in our State. The species was first described from the Trenton limestone of Ottawa (Can. Pal. Fossils, 1865, 1:182); later a doublure of a head shield from the Galena of Wykoff, Minnesota, was also referred with doubt to this species by Doctor Clarke (title 32, page 757). Weller (title 53, page 191) has also recognized the species in the fauna from the Jacksonburg limestone at Jacksonburg, N. J., and Bassler (title 62, page 111) lists it from the Liberty Hall limestone (Chazy) of Virginia.

Our specimen has been slightly laterally compressed and therefore appears somewhat more slender than the type, but otherwise it fully agrees with the original drawing of the latter. It also distinctly exhibits the surface punctae characteristic of Billings's species.

Isotelus gigas DeKay

Pl. 10, fig. 1

We figure here a fairly well-preserved specimen of this widely known trilobite which, labeled as coming from the bluestone quarries at Rexford Flats, N. Y., has been in the State Museum

for some time. It is the only example of this species known to us from the Schenectady beds and appears to agree in all essential characters with the Trenton type. The fact that it is narrower and higher is due to lateral compression.

Proëtus undulostriatus (Hall)

Pl. 9, fig. 2, 3

Olenus undulostriatus Hall. Pal. N. Y., 1847, 1:258, pl. 67, fig. 3a, b.

Cf. Proëtus parviusculus Hall. 13th An. Rept. N. Y. State Mus. Nat. Hist., 1860, p. 120.

Elliptocephala undulostriata S. A. Miller. North Amer. Geol. & Pal., 1889, p. 546.

Bathyurus sp. Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., pt. 1, 1898, 11:70, 71.

Proëtus parviusculus Ruedemann. N. Y. State Mus. Bul. 42, 1901, p. 536.

Cyphaspis hudsonica Ruedemann. N. Y. State Mus. Bul. 49, 1901, p. 64, pl. 4, figs. 8, 9.

The writer described in 1901 several small cranidia from the black limestone pebbles from the Rysedorph Hill conglomerate which are especially characterized by a fine system of transverse or concentric sculpture lines, as Cyphaspis matutina, and another cranidium of broader habit from the supposed Upper Utica shale of Green island as C. hudsonica. Collecting in the Snake Hill beds at Snake hill furnished a few years ago a cranidium (plate 9, figure 3) which not only exhibits the identical characteristic sculpture of C. matutina but also resembles it in all other features with the exception that it is a little broader and the frontal limb distinctly narrower. In the latter features it fully agrees with the C. hudsonica which comes from beds which we now know to be identical with the Snake Hill beds. This latter specimen proves on reinvestigation to be exfoliated, for which reason the surface sculpture is not observable while the glabellar furrows are more distinct.

Hall had in 1847 described and figured as Olenus undulostriatus from the "Hudson River group" of Snake hill, the mold of a carapace and part of the thorax of a trilobite which since that author had referred in his early work a considerable number of Lower Cambric fossils to the "Hudson River group," had also been placed by catalogers in the Cambric, or rather since the original description is very brief and the figure quite unsatisfactory, it has

been left out of consideration in discussions of the Lower Siluric faunas. Hall's type, which was kindly loaned to us by Dr E. O. Hovey, proved, from gutta-percha squeezes, to be specifically identical with the specimens in our collection from Snake hill and also with the other specimen formerly described by us as Cyphaspis hudsonica. We have here (plate 9, figure 2) introduced a new figure of the original of Olenus undulostriatus from a gutta-percha squeeze.

While Hall referred his species to Olenus and Miller placed the same under Elliptocephala, Whitfield and Hovey in the catalog of palaeontologic types of the American Museum of Natural History, have cited that type as Bathyurus sp.

We had placed the cranidia from the Rysedorph Hill conglomerate and of Green island with Cyphaspis on account of the form of the glabella and the large basal lobe. From inspection of the whole carapace and the thorax we have however become convinced that those species should be more properly referred to Proëtus, the isolation of the basal lobe being too indistinct for Cyphaspis and the carapace relatively too broad and the glabella not prominent enough. On the other hand, while we recognize the similarity of the carapace of P. undulostriatus to that of Bathyurus in its former generalized conception, we doubt that this genus, as characterized by its genotype, B. extans (Hall), could be made to receive forms like the present with a distinct thick anterior margin and a much broadened base of the glabella through a more or less prominent basal lobe. All these are features characteristic of Proëtus and are becoming still more emphasized in Cyphaspis, but absent in Bathyurus.

Proëtus matutinus Ruedemann from the Rysedorph Hill conglomerate is obviously a closely related older form, the black pebbles being probably of Black River and the Snake Hill beds of Trenton age. It is mainly distinguished by the broader frontal limb of the cranidium. The glabella is also distinctly more convex, but this may be due to the preservation in limestone, the shale fossils always being more or less flattened. The fine anastomosing sculpture lines are identical in P. undulostriatus and matutinus.

In New York State Museum Bulletin 42, 1901, page 536, the present writer has cited from the "Middle Trenton shales," exposed at the Brothers quarry at South Troy, Proëtus parvius-culus Hall, from a cranidium collected by him at that locality.

The same is now packed away and at present not accessible, but the writer feels sure that this cranidium also belongs to P. undulostriatus from his recollection of the minute fossil and from the fact that P. parviusculus is clearly a very close relative of P. undulostriatus. The small specimen from Troy was exfoliated and therefore failed to show the striae.

P. parviusculus in size and outline of carapace and glabella would appear to be difficult of differentiation from the Snake Hill species. The fact that its surface is described as " smooth, or very finely granulose " would seem to furnish a distinctive character.

Beecher (1895, p. 174) states, however, regarding the surface sculpture of this species: " In the original description of this species, no mention was made of fine undulating striae ornamenting the entire dorsal surface of the test, nor of the basal lobes of the glabella. Both these features are present in the type specimen, which is from Cincinnati, Ohio, as well as in all the specimens from the Utica slate near Rome, New York."

If it were not for the fact that the cheeks and glabella of the types of P. undulostriatus and P. hudsonicus are relatively broader than those figured of P. parviusculus and the genal spines diverging instead of being subparallel, we should not hesitate to consider parviusculus a synonym of the older term. Since these differential characters in the scant material at our disposal — and especially in the type specimen — may be due to longitudinal compression, it is possible that later collections will demonstrate the identity of the Cincinnati and Snake Hill forms. At any rate, if different, they are very closely related.

The species here described presents in its outline great similarity to Proëtus latimarginatus Weller from the Jacksonburg limestone of New Jersey. The latter type is however described as possessing a finely granulose surface.

Acidaspis crossota (Locke)

Pl. 9, figs. 4, 5

A small Acidaspis from the Indian Ladder beds, represented by a cranidium and several fine cheeks, has been identified by Doctor Ulrich with Acidaspis crossota Locke, a form hitherto known only from the Cincinnati group of the neighborhood of Cincinnati. It is recorded by Nickles as ranging through the Eden (" Utica ") shale of Cincinnati.

Calymmene senaria Conrad

Pl. 9, fig. 6–10

The Canajoharie shale in the Mohawk valley often contains as one of its more frequent fossils quite large specimens of Calymmene senaria. These, as first noticed by Doctor Ulrich, bear upon the occipital ring a larger median tubercle not found in the common Trenton or Utica specimens and obviously representing a varietal character. It is distinctly seen on the specimen reproduced in figure 6, but the largest specimen here figured also possessed a larger, though flatter elevation upon the middle of the occipital ring.

The material of this species from the Canajoharie shale proved especially interesting through the fact that the fine black shale has retained the earlier growth stages. Among the latter was found a well-preserved specimen of a protaspis (see plate 9, figure 7), which to our knowledge has not as yet been observed of this genus. The very prominent marginal eyes and the fine segments of the glabella, the middlemost of which is largest, are the most striking features of this trilobite embryo. We also figure a nepionic and early neanic stage to illustrate the changes in the glabella, leading to the suppression of the embryonic annulations. The protaspis here figured is practically identical with that referred to Proëtus parviusculus by Beecher,[1] and the question arises whether it should not also be referred to that genus. Since our protaspis is fairly well connected with the adult Calymmene by the neanic stages here figured, and Proëtus parviusculus has not been found associated with it in the Canajoharie beds; we feel certain of its ontogenetic connection with the common Calymmene senaria of that formation.

Ulrichia ? bivertex Ulrich

Pl. 9, fig. 11, 12

Associated with Primitiella unicornis the Canajoharie shale at Canajoharie contains in considerable numbers an ostracod of rather striking appearance through two prominent tubercles near the dorsal margin. This species was first published by Doctor Ulrich as Leperditia bivertex (title 8, page 10) from the neighborhood of Cincinnati and is now referred by him to

[1] The larval stages of Trilobites. Amer. Geologist 16, pl. 9, figs. 5, 6.

the genus Ulrichia with some doubt. It is usually as at Canajoharie associated with Primitiella unicornis in the lower Trenton and in the " Utica " of Cincinnati.

Eurychilina subradiata Ulrich

Pl. 9, fig. 16

A specimen of this species which has been recorded by Doctor Ulrich (Jour. Cin. Soc. Nat. Hist., 1890, 13:126; Geology of Minnesota, part 2, 1897, 3:661) from "Birdseye and Lower Trenton" of the Middle West (Minnesota-Tennessee) was also collected in the shaly basal Trenton of the Canajoharie section. The New York type is according to Doctor Ulrich a close derivative of the western form which is there a good Black River species.

Primitiella unicornis Ulrich var.

Pl. 9, fig. 13, 14

This minute ostracod was first made known by Doctor Ulrich in 1879 (title 8, page 10, plate 7, figure 4), and later more fully described and illustrated in the Geology of Minnesota (title 38, page 649). It is stated by its author to occur abundantly in the lower part of the Cincinnati group about Cincinnati and also recorded by the same authority from near the base of the " Hudson River group " in Minnesota and in a slightly different variety from Manitoba (title 15, page 50). Professor Nickles (title 49, page 71) records it from his lowest division of the " Utica " at Cincinnati. Doctor Ulrich has denoted the Canajoharie form as corresponding to the " basal Trenton variety." This variety appears to us to be distinct from the type of the species in being more elongate and thicker in the posterior part. The spine is somewhat larger and the slight node in the dorsal depression larger.

It has been observed by us in this State only in the lower part of the Canajoharie shale.

Ceratopsis chambersi (Miller) var.

Pl. 9, fig. 15

The Indian Ladder beds at the Indian Ladder have furnished us an ostracod which like many of its associated forms has before been only known from the Cincinnati region, whence it was first described

by S. A. Miller (Cincinnati Quar. Jour. Sci., 1874, 1:234) and from the West. It has been more fully made known by Doctor Ulrich (Jour. Cinc. Soc. Nat. Hist., 1890, 13:112; Geology of Minnesota, part 2, 1897, 3:676).

This species which in several varieties occurs in the Trenton, Cincinnati and Richmond formations, is characterized by the spine-like form of the postdorsal process. Our specimen represents a variety that may be peculiar of the Indian Ladder beds. One of its features is the separate development of the upper end of the post-medium ridge as a small rounded node. Doctor Ulrich (op. cit. page 676) figures a similar specimen and remarks that it is the only case of the kind seen and may be abnormal.

Pollicipes siluricus Ruedemann

In New York State Museum Bulletin 42 (1901, page 518) the writer described as Pollicipes siluricus a crustacean from the Snake Hill beds of Green island, N. Y., announcing it as the first lepadid or "goose barnacle" yet known from the Paleozoic. He has since learned that Dr W. S. Aurivillius had before (Bihang Svenska Vet.-Akad. Handl., 28, Afd. 4, No. 3, 1892) made known two species of Pollicipes and seven of Scalpellum from the Upper Siluric of Sweden, thus leaving to the Snake Hill barnacles only the distinction of being the first Lower Siluric or Ordovicic ones known.

In a note on the geologic distribution of Pollicipes and Scalpellum by Doctor Bather (title 46, page 112) this author suggests that my figures of Pollicipes siluricus belong to more than one species and that therefore a holotype of P. siluricus should be selected and the species separated. Although Aurivillius's species are based on differences in form of plates etc. of no greater amount than those in our material, we do not deem it safe at present to distinguish more than one species for the reason that the plates have suffered distortion in the much contorted shales, and we therefore restrict ourselves here to designating the original of figure 17, plate 2, *op. cit.* as the holotype.

Technophorus cancellatus Ruedemann

Pl. 9, fig. 17, 18

This peculiar fossil has been described by the writer (title 47, page 572) from the shale of Green island, Albany county, N. Y., then referred to the Utica, where it occurs in the same association as

found on Snake hill. We figure here two specimens showing additional features. Our species is a very close ally of T. punctostriatus Ulrich (title 22, page 685) from the Cincinnati group, with which it has above all the striking surface ornamentation in common. Doctor Ulrich writes me that T. cancellatus has a proportionally greater length and more prominent rostrum. Since T. punctostriatus occurs in the middle beds of the Cincinnati group it is also considerably younger than the Snake Hill species.

Miller considered his genus Technophorus as belonging to the lamellibranchs and Ulrich (title 38, page 612) retained the genus in that class, pointing out, however, that in the surface ornamentation and the character of the beaks as they appear in casts of the interior, the genus differs from all known Paleozoic representatives of the class, with the possible exception of Ischyrina Billings.

The markings are such as to suggest the crustacean nature of Technophorus and the beaks form a single pyramidal prominence instead of two separate points as in lamellibranchs. The Snake Hill species seems to be distinguished from the others by an especially prominent beak (plate 9, figure 18).

Doctor Clarke in describing a very similar fossil from the Oneonta sandstone (New York State Museum Memoir 6, part 2, 1904, page 406) has stated that he is "more inclined to regard these clavicle-bearing genera (Technophorus and Ischyrina) as bodies like Ribeiria and Ribeirella which Schubert and Waagen have shown to be apodiform crustaceans (Jahrb. der k. k. geol. Reichsanst. 1903, 53:337), adding that "it is doubtless true that Technophorus is a ribeirioid crustacean." Doctor Ulrich now also considers these genera as crustaceans.

EXPLANATION OF PLATES

Plate 1

Spnenophycus latifolius (Hall)

Page 73

Fig. 1 Example resembling Hall's type.
Fig. 2 Lobate thallus, showing short conical marginal cavities.
Fig. 3 A large fragment of thallus, showing at the right lower margin the cavities, giving it a lobate appearance.
Fig. 4 A thallus showing very distinctly the conical marginal cavities.
Fig. 5 Large thallus with radiating impressions and cavities.
Fig. 6 Small thallus showing perfect margin with cavities.
Fig. 7 Thallus with complete outline.
Fig. 8 Thallus with broad, partly overlapping lobes.
Fig. 9 Thallus showing parallel, distally diverging lines and a medial row of double pits, doubtfully referred here.
Fig. 10 Thallus with extremely lobate outline. The specimens, figures 4–6, 8–10, only doubtfully referable to this species.

Horizon and locality. Schenectady beds. Aqueduct near Schenectady, N. Y. All figures are natural size. The originals are in the State Museum.

G. S. Barkentin del.

Plate 2

Sphenophycus latifolius (Hall)

Page 73

Fig. 1–4 Specimens showing the more common aspects of the fossil Natural size. Figure 1 shows also a bandlike breaking up of the test; figure 2, the most frequent and typical aspect of the bodies; figure 3, showing a breaking of the stem into longitudinal shreds at *b;* figure 4, specimen with long, thin pedicel.

Fig. 5 Specimen in which the upper test has become exfoliated, revealing a flattened interior space.

Fig. 6 Specimen in which the wrinkling suggests the originally inflated condition of the bulb; it also shows a bandlike shred of the pedicel.

Fig. 7, 8 Specimens remarkable for the extreme inflation of the bulb. Figure 8 shows at *b* a cylindrical section of the pedicel.

Fig. 9 Specimen showing a marginal, distal wrinkle and slight extension resulting from the flattened apex of the bulb, folded upon itself.

Fig. 10 Specimen also distinctly showing the apical wrinkle or fold, and a slight inflation in the pedicel.

Fig. 11 Finely preserved specimen showing the flattened oval space at the top of the bulb and a bulbous swelling of the pedicel (at *a*).

Fig. 12 Specimen showing finely the apical flattening of the bulb with a central, probably accidental perforation.

Fig. 13 Fragment of fronds of Sphenophycus latifolius, showing their spiral arrangement and the stems of several specimens of bulbs.

Fig. 14 Circular, originally probably spherical body found associated with the bulbs.

Figure 9–12 are x 2; the others natural size.

Horizon and locality. Schenectady beds. Aqueduct near Schenectady, N. Y.

Dictyonema arbuscula (Ulrich)

Page 77

Fig. 15 Specimen in natural size.

Horizon and locality. Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Dictyonema multiramosum nov.

Page 78

Fig. 16 Holotype. Natural size.

Horizon and locality. Schenectady beds. Rotterdam Junction, Schenectady county, N. Y.

Diplograptus peosta Hall

Fig. 17 Specimen in natural size from Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Diplograptus (Mesograptus) mohawkensis nov.

Page 80

Fig. 18 Typical (holotype) specimen from Canajoharie shale, Swartztown creek near Amsterdam, N. Y. Natural size.

Fig. 19 Specimen (paratype) from Canajoharie shale at the Carlsbad Spring near Saratoga Springs, N. Y.

Diplograptus (Amplexograptus) macer nov.

Page 82

Fig 20, 21 Cotypes. Natural size. Uppermost Canajoharie shale at Minaville, Montgomery county, N. Y.

The originals are in the New York State Museum.

G. S. Barkentin del.

Plate 3

Taeniaster schohariae nov.

Page 88

Fig. 1 Holotype. x 5. The middle arm exhibits the ventral view.
Upper Schenectady beds near Schoharie Junction, Schoharie county, N. Y.

Edrioaster saratogensis nov.

Page 86

Fig. 2 Holotype. x 5. Specimen showing the five ambulacral rays, oval aperture, subambulacral plates (at *a*) and the inner thecal plates of the interambulacra.

Fig. 3 Paratype. x 5. Specimen showing three of the oral plates, distinctly the suture-lines of one interambulacrum and what is apparently an anal pyramid (at *a*).

Fig. 4 Paratype. x 5. A badly crushed specimen which however well exhibits the extremital part of an ambulacral ray at *b;* and the subambulacral pavement of plates at *a*.

Snake Hill beds at Snake hill, Saratoga county, N. Y.

Heterocrinus ? gracilis Hall

Page 86

Fig. 5 A specimen from the original locality of the species. Natural size.
Snake Hill beds at Snake hill, Saratoga county, N. Y.

Carabocrinus cf. **radiatus** Billings

Page 86

Fig. 6 A calyx plate. Natural size.
Snake Hill beds at Snake hill, Saratoga county, N. Y.

All figures are taken from squeezes. The originals are in the New York State Museum.

S. Barkentin del.

Plate 4

131

4

Lingula rectilateralis Emmons

Page 91

Fig. 1 Specimen figured in natural size.
Schenectady beds. Dettbarn quarry, Schenectady, N. Y.

Orbiculoidea tenuistriata Ulrich

Page 91

Fig. 2 Pedicle valve. x 4.
Top of Frankfort shale, Frankfort gulf, N. Y.

Plectambonites sericeus (typus) Sowerby

Page 91

Fig. 3, 4 Two pedicle valves, showing the mesial fold. Figure 7 x 2; Figure 8 x 3.
Fig. 5 Brachial valve. x 2. From squeeze.
Fig. 6 Interior of brachial valve. x 2. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plectambonites centricarinatus nov.

Page 92

Fig. 7 Holotype. Pedicle valve. x 4.
Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Plectorthis sp. cf. **whitfieldi** (N. H. Winchell)

Page 92

Fig. 8 Brachial valve. Natural size. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plaesiomys retrorsa (Salter)

Page 93

Fig. 9 Brachial valve. Natural size. From squeeze.
Fig. 10 Cardinal portion of brachial valve. x 2. From squeeze.
Fig. 11 Pedicle valve. Natural size.
Fig. 12 Enlargement (x 5) of surface.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plaesiomys cf. **porcata** McCoy

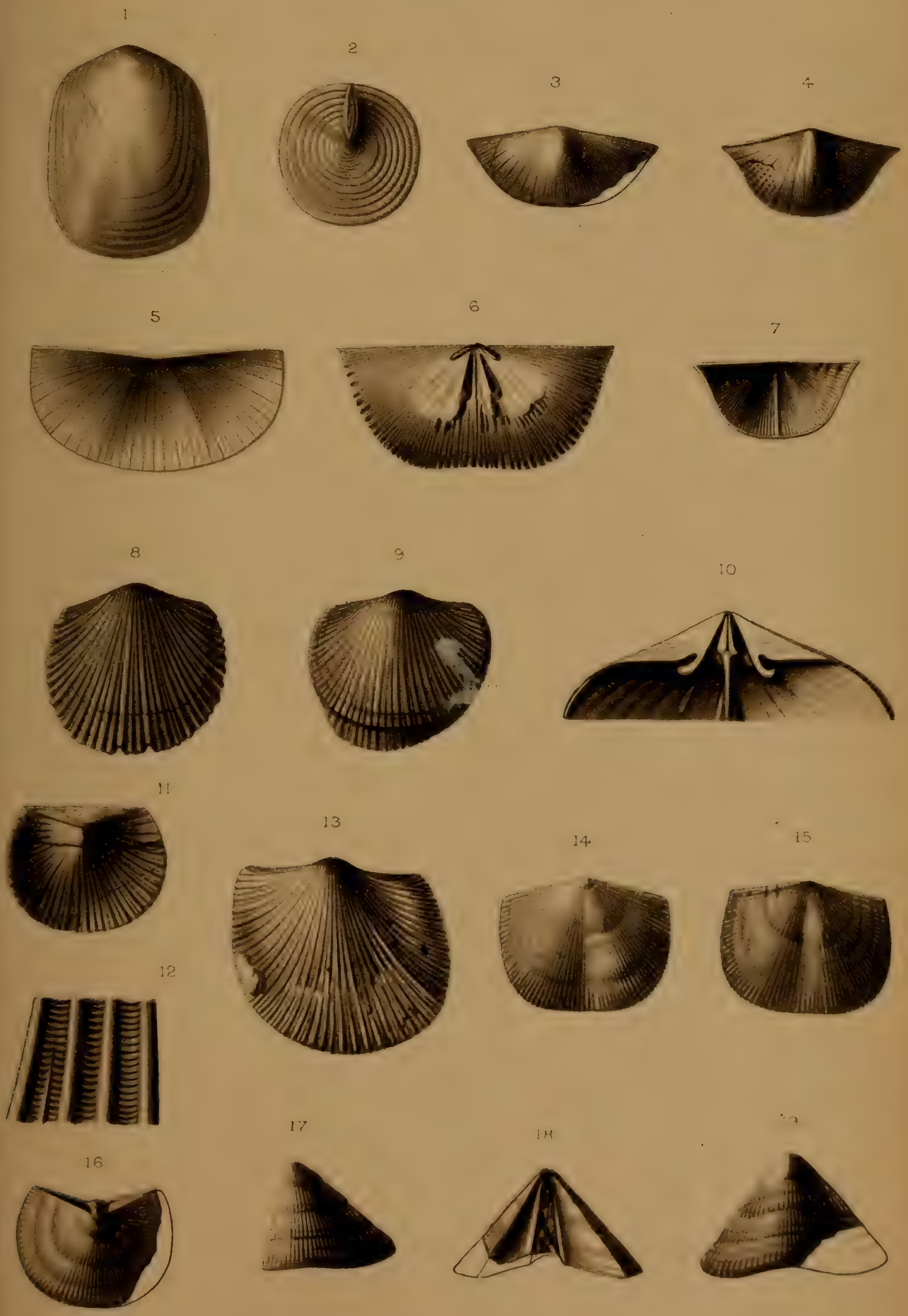
Page 93

Fig. 13 Pedicle valve. Natural size. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clitambonites americanus (Whitfield)

Page 94

Fig. 14, 15 Two views of brachial valves. Natural size.
Fig. 16–19 Views of the pedicle valve. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.
All originals are in the New York State Museum.



G. S. Barkentin del.

Plate 5

Whiteavesia cincta nov.

Page 95

Fig. 1 Holotype. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Whiteavesia cumingsi nov.

Page 96

Fig. 2 Specimen that is probably but little distorted. Holotype. x 2.
Fig. 3 Another specimen, showing a frequent expression of the form. Paratype. x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Prolobella ? trentonensis (Conrad)

Page 97

Fig. 4 Specimen. x 2.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Orthodesma ? subcarinatum nov.

Page 96

Fig. 5, 6, 7 Specimens (cotypes) showing the more frequent and apparently least distorted appearances of the species in the folded shales of Snake hill. x 1.5.
Fig. 8 Dorsal view. x 1.5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Whitella elongata nov.

Page 98

Fig. 9 Holotype. Natural size.
Fig. 10 Dorsal view of same.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clidophorus ventricosus nov.

Page 99

Fig. 11, 12 Lateral and anterior views of the holotype. x 3.
Fig. 13 A more elongate specimen showing hinge-denticles. x 1.5.
Fig. 14 A specimen with very distinct clavicle. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clidophorus foerstei nov.

Page 99

Fig. 15, 16 Lateral and vental views of the holotype. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.
All originals are in the New York State Museum.

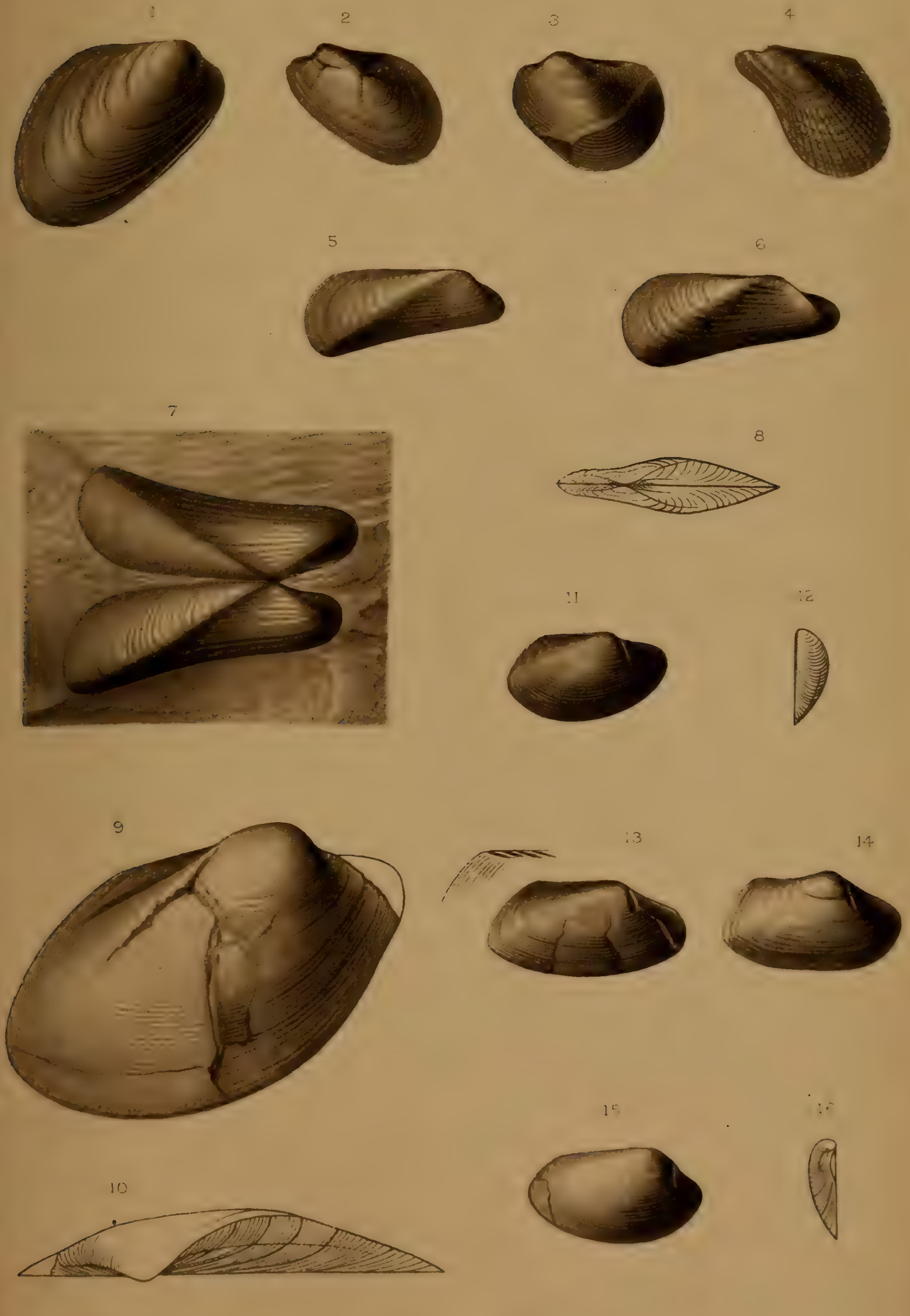


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Plate 6

Ctenodonta levata (Hall)

Page 100

Fig. 1 Right valve. x 2.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta declivis nov.

Page 101

Fig. 2, 3 Lateral and posterior view of holotype. x 2.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta prosseri nov.

Page 101

Fig. 4, 5 Lateral and posterior views. x 4.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta radiata nov.

Page 102

Fig. 6 Lateral view of holotype. Natural size.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta recta nov.

Page 102

Fig. 7, 8 Lateral and posterior views of holotype. x 3.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta subcuneata nov.

Page 103

Fig. 9, 10 Lateral and posterior views of holotype. x 1.5.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Allodesma cf. **subellipticum** Ulrich

Page 103

Fig. 11 Specimen. x 2.

Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Lyrodesma schucherti nov.

Page 103

Fig. 12 Holotype. x 2.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Solenomya ? insperata nov.

Page 105

Fig. 13, 14 Two specimens (cotypes) showing the common expression of the form. x 1.5.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Cuneamya acutifrons Ulrich

Page 106

Fig. 15 Anterior portion of specimen. Natural size.

Fig. 16 Surface sculpture. x 8.

Snake Hill beds. Snake hill, Saratoga county, N. Y.

Saffordia ulrichi nov.

Page 107

Fig. 17, 18 Lateral and anterior views of holotype. Natural size.

Schenectady beds. Schenectady, N. Y.

All originals are in the New York State Museum.

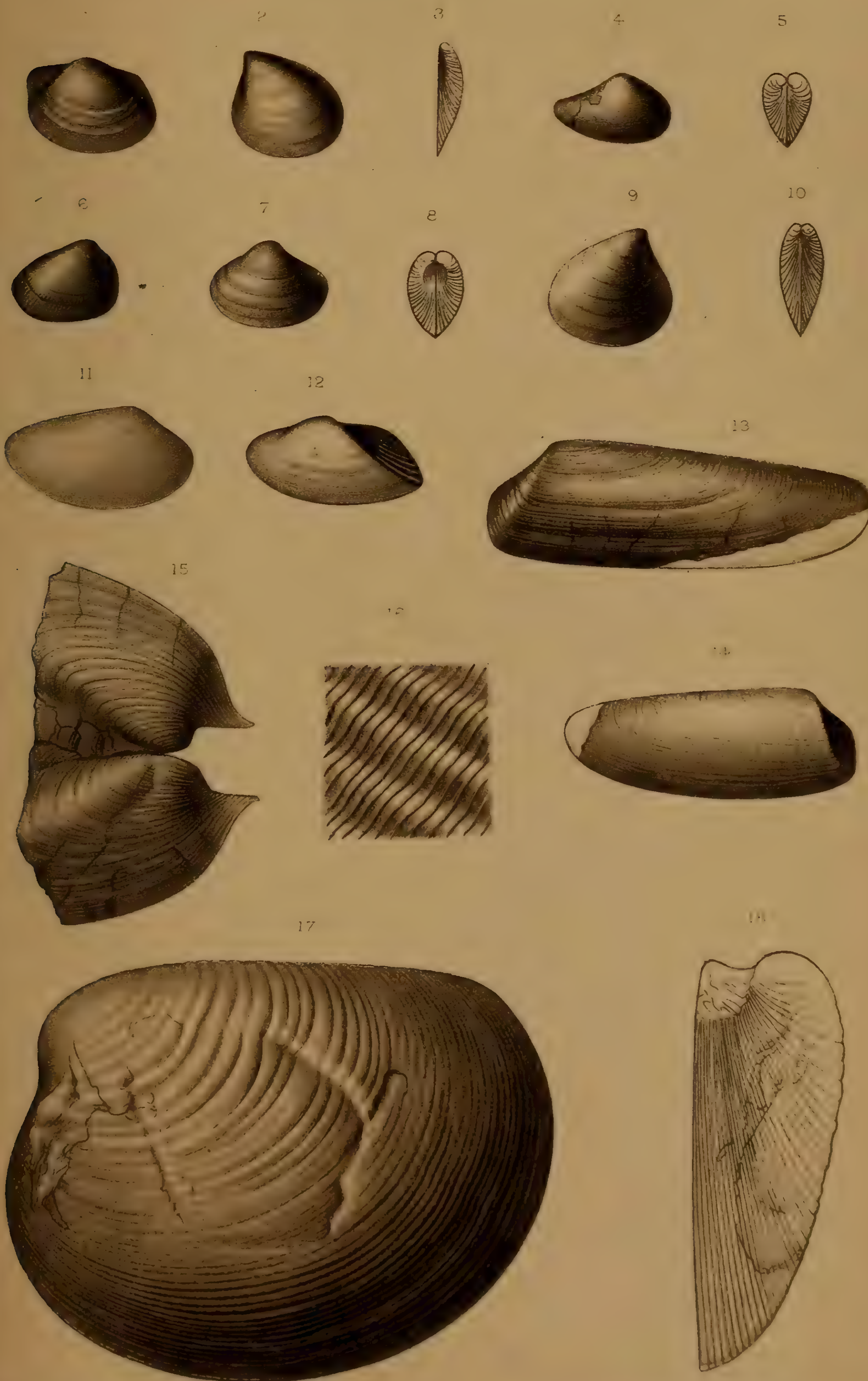

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Plate 7

Archinacella orbiculata (Hall)

Page 108

Fig. 1, 2 Very little distorted specimens. x 2. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Fig. 3, 4, 5, 6 Dorsal and lateral views of Hall's types. x 2.
Snake Hill shale. Near Waterford, N. Y.

Cyclonema montrealense Billings

Page 110

Fig. 7 Specimen. x 1.5. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Cyclonema cushingi nov.

Page 110

Fig. 8 Surface of holotype. Natural size. From squeeze.

Fig. 9 Cast of interior of same.

Fig. 10 Surface sculpture. x 5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Pterotheca cf. **canaliculata** (Hall)

Fig. 11 Specimen, somewhat crushed. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Hyolithes pinniformis nov.

Page 111

Fig. 12 Holotype, showing a septum near the apex. x 5.

Fig. 13 Paratype. x 5.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

All originals are in the New York State Museum.

G. S. Barkentin del.

Plate 8

Orthoceras arcuolineatum nov.

Page 112

Fig. 1 Holotype. Natural size.
Fig. 2 Section of same.
Canajoharie shales. Fort Edward, Saratoga county, N. Y.

Orthoceras hudsonicum nov.

Page 112

Fig. 3 Fragment showing the septa and surface sculpture. Natural size.
Fig. 4, 5 Two specimens showing the protoconch. x 5.
Fig. 6 Section of same, showing the first funnel at *a*. x 5.
Fig. 7 Straight specimen, from the Schenectady beds at the Dettbarn quarry near Schenectady and possibly different. Natural size.
Fig. 8, 9 Specimens that are slightly curved in the apical (neanic) region. Natural size.
Fig. 10 Section of neanic conch showing the closely arranged septa. Natural size.

The holotype (fig. 8) and the originals (paratypes) of figures 4, 5, 6, 9, 10 are from the Canajoharie beds at Alplaus; the original of figure 3 is from Watervliet, and that of figure 7 from the Dettbarn quarry at Schenectady.

Orthoceras cf. **amplicameratum** (Hall)

Fig. 11 Fragment, much compressed. Natural size.
Canajoharie shale. Near Glens Falls, N. Y.

Oncoceras (?) sp.

Page 115

Fig. 12 A completely flattened specimen.
Snake Hill beds. Signal Works near Albany, N. Y.
All originals are in the New York State Museum.

S. Barkentin del.

Plate 9

Eoharpes ottawensis (Billings)

Page 116

Fig. 1 Specimen, somewhat laterally compressed. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Proëtus undulostriatus (Hall)

Page 117

Fig. 2 Hall's type. x 3. From squeeze.
Fig. 3 Cranidium. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Acidaspis crossota (Locke)

Page 119

Fig. 4 Free cheek. x 6.
Fig. 5 Cranidium. x 5.
Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Calymmene senaria Conrad var.

Page 120

Fig. 6 Young, fairly complete individual, showing the medial tubercle on the occipital ring. Natural size.
Fig. 7 Protaspis stage. x 20.
Fig. 8 Nepionic stage. x 20.
Fig. 9 Early neanic stage, showing the appearance of the glabellar lobes in the glabellar furrows. x 20.
Fig. 10 Mature individual, much flattened. Natural size.
Canajoharie shale. Canajoharie and Sprakers (figure 10), Montgomery county, N. Y.

Ulrichia ? bivertex Ulrich

Page 120

Fig. 11 Right valve, showing normal expression of form. x 20.
Fig. 12 A left valve with slightly different aspect. x 20.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Primitiella unicornis Ulrich var.

Page 121

Fig. 13, 14 Two right valves showing the elongate form and the lateral node. x 20.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Ceratopsis chambersi (Miller) var.

Page 121

Fig. 15 Left valve showing the average expression of the variety.
Indian Ladder beds. Indian Ladder, Albany, N. Y.

Eurychilina subradiata Ulrich

Fig. 16 Right valve. x 10.
Glens Falls limestone. Canajoharie, Montgomery county, N. Y.

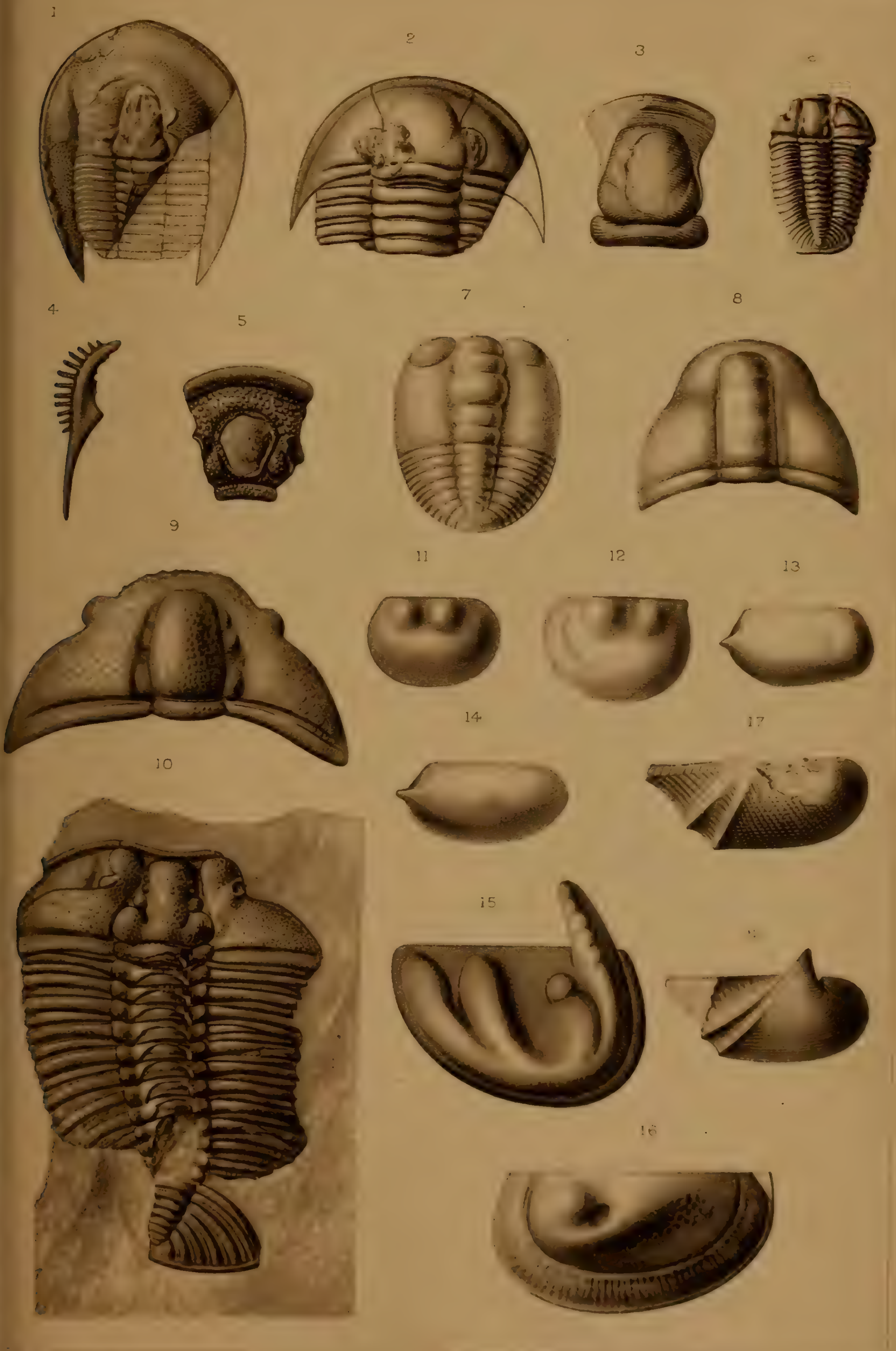
Technophorus cancellatus Ruedemann

Page 122

Fig. 17 Right side of a somewhat imperfect carapace, retaining the surface sculpture. x 4.

Fig. 18 Cast of the interior of the right side retaining the undivided "beak." x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

All originals are in the New York State Museum.



I. S. Barkentin del.

Plate 10

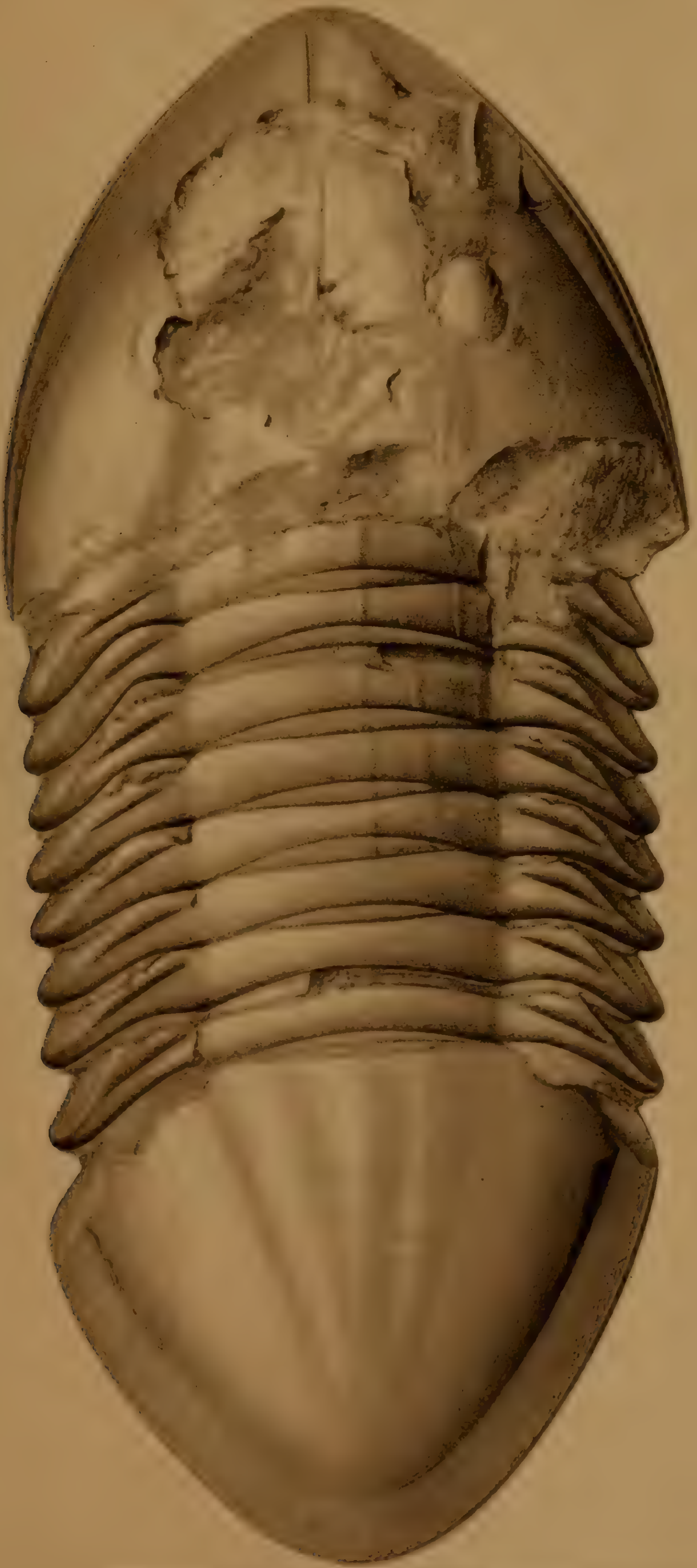
143

Isotelus gigas DeKay

Page 116

Fig. 1 Specimen somewhat laterally compressed, reproduced in natural size.

Schenectady beds. Rexford Flats, Saratoga county, N. Y. Original in the New York State Museum.



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INDEX

Page numbers referring to descriptions of fossils are printed in black face type.